

The University of Chicago

SUBSURFACE GEOLOGY
OF THE
MARSEILLES, OTTAWA, AND STREATOR QUADRANGLES
AND VICINITY

AN EXPANSION OF A DISSERTATION SUBMITTED
TO THE FACULTY OF THE DIVISION OF THE
PHYSICAL SCIENCES IN CANDIDACY FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF GEOLOGY AND PALEONTOLOGY

1938

By
J. NORMAN PAYNE

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CHAPTER IV—SUBSURFACE STRATIGRAPHY

BY
J. NORMAN PAYNE

The bedrock in the Marseilles, Ottawa, and Streator quadrangles ranges in age from pre-Cambrian to Pennsylvanian. Although the bedrock is concealed over the greater part of the area by glacial drift, there are numerous more or less limited outcrops and a large number of well logs by means of which it is possible to obtain a fairly accurate picture of the relationships and characters of the pre-Pleistocene formations and of the structural conditions.

All of the formations of the Marseilles-Ottawa-Streator area, with the exception of pre-Cambrian formations, are composed of sedimentary rocks. Pre-Cambrian rocks do not crop out in Illinois. However, several wells drilled in the northern part of the State have penetrated red "granite" of pre-Cambrian age.

As the stratigraphy of the outcropping Ordovician and of the Pennsylvanian formations is covered in the succeeding chapters of this report, this one deals only with the characters and relationships of pre-Cambrian, Cambrian, Ordovician, and Silurian formations as revealed from a study of sample-cuttings and logs of various types of borings drilled throughout the area.

In order to obtain more adequate knowledge of these formations within the quadrangles the study was expanded to cover a much larger area, of which the quadrangles are approximately the center (fig. 1 and pls. 13-27)*, and it is this larger

area that is meant wherever the words "the region" or "north-central Illinois" are used.

PRE-CAMBRIAN SYSTEMS

The well nearest to the Marseilles, Ottawa, and Streator quadrangles which penetrated pre-Cambrian strata is the Amboy Oil and Gas Company well on the McElroy farm in the SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 30, T. 20 N., R. 10 E., Lee County (app. C, 7). This well entered red "granite" at a depth of 3760 feet or an elevation of 3046 feet below sea-level. The upper part of the pre-Cambrian strata underlying north-central Illinois is probably composed of the same type of material as encountered in this well.

CAMBRIAN SYSTEM¹

The Cambrian rocks of the region, which are known only from study of well-cuttings, are of Upper Cambrian or St. Croixan² age. A study of the variations in thickness of some of the upper formations of the St. Croixan series indicates that its aggregate thickness ranges from a maximum of about 2800 feet in an east-west belt across the northern half of the Marseilles and Ottawa quadrangles to a minimum of 2500 feet in the northern part of the Streator and central parts of the Marseilles and Ottawa quadrangles (pls. 14, 16).

¹The Cambrian system derives its name from Cambria, the Roman name for northern Wales, where the rocks of this system are typically exposed. Sedgwick, Rev. A., Edinburgh New Philos. Jour., vol. 19, p. 390, Aug. 14, 1835, Abst.

²The name St. Croixan was given to this series of rocks by N. H. Winchell from exposures along the St. Croix River, Minnesota. Winchell, N. H., Sketch of the Geology of Minnesota: Geol. and Nat. Hist. Survey of Minnesota, First Ann. Rept. for 1872, p. 70, 1873.

*The wells whose locations are shown on plates 13-27 are those which were drilled and for which records were available as of April 1, 1941. The available records of numerous wells that have been subsequently drilled confirm the areal distribution of the formations as shown on the plates.

In ascending order Cambrian formations in the region are Mt. Simon, Eau Claire, Galesville, Franconia, Trempealeau, and Jordan formations.

DRESBACH GROUP^{3,4}

The Dresbach group consists of the Mt. Simon, Eau Claire, and Galesville formations. These formations are composed predominantly of sandstone with subordinate amounts of dolomite and shale.

MT. SIMON FORMATION⁵

Distribution.—Because the Mt. Simon sandstone has been penetrated to varying depths in several wells in and near north-central Illinois, and because it is several hundred feet thick throughout northern Illinois, it doubtless underlies the entire region.

Lithology.—In the McElroy well mentioned above (app. C, 7) in which the complete thickness of the Mt. Simon formation was penetrated, it consists of five fairly well defined zones as follows:

	Ft.
Zone 5. Sandstone, pink to yellow, dominantly coarse-grained, interbedded with variegated micaceous shales and occasional conglomeratic layers	545
Zone 4. Sandstone, variegated, very fine- to coarse-grained, partly conglomeratic, interbedded prominently with purple and yellow granular conglomerate, with some purple sandy shale in the lower 20 feet	195
Zone 3. Sandstone, variegated, fine- to coarse-grained, partly silty, with some sandy, gray to brown shale at top	490
Zone 2. Sandstone, variegated, fine- to coarse-grained, containing scattered grains and pebbles of granite and feldspar	260
Zone 1. Sandstone, variegated, arkosic, medium- to coarse-grained, with some interbedded red to green micaceous shale in the lower half	200

Thickness.—According to the variation in thickness of other Cambrian formations, the maximum thickness of the Mt. Simon formation is estimated to be about 1700 to 1750 feet in the north part of the Marseilles and Ottawa and the extreme south part of the Streator quadrangles, and the minimum to be probably about 1600 feet in the central and south parts of the Marseilles and Ottawa and the north part of the Streator quadrangles.

Stratigraphic relations.—The Mt. Simon sandstone rests unconformably on the eroded pre-Cambrian bedrock and is succeeded with probably slight disconformity by the Eau Claire formation.

Correlation.—On the basis of its lithology and stratigraphic position the Mt. Simon sandstone in north-central Illinois is correlated with the Mt. Simon formation of Wisconsin. However, because the character of the material in zone 1 suggests that it is of terrestrial origin, with the basal shale portion possibly representing weathered regolith of the pre-Cambrian formations, the zone may be older than the Mt. Simon and possibly equivalent, at least in part, to the Hinckley sandstone at Hinckley, Minnesota. The occurrence of scattered feldspar and granite in zone 2 is not contrary to this view, as the reworking of the materials in an advancing sea would distribute them for some time.

EAU CLAIRE FORMATION⁶

Distribution.—The Eau Claire formation doubtless underlies the entire region, as there is no evidence of its nondeposition or of its complete removal by erosion in any part of the region.

Lithology.—The Eau Claire formation consists of dolomitic sandstones and shales and sandy dolomites which may be divided into three zones as follows:

³The name Dresbach was first used in 1886 for sandstone quarried along Mississippi River at Dresbach, Minnesota. Winchell, N. H., *Geology of Minnesota: Geol. and Nat. Hist. Survey of Minnesota, Final Report*, vol. 2, preface, p. 22, 1888.

⁴In earlier reports on Illinois geology the sandstone lying between the Eau Claire formation below and the Franconia formation above was thought to be equivalent to the Dresbach sandstone at the type locality of Minnesota. Recently Trowbridge and Atwater (*Stratigraphic Problems in the Upper Mississippi Valley: Geol. Soc. America Bull.*, vol. 45, pp. 21-80, Feb. 28, 1934) found that the type section of Dresbach includes part of the Eau Claire formation, and proposed that the Dresbach be expanded to include the Mt. Simon and the Eau Claire formations and that these as well as the upper sandstone, for which they proposed the name Galesville, be reduced to the rank of members. The Illinois Survey has accepted the name Galesville, but because of their magnitude and consistency it considers the Mt. Simon, Eau Claire, and Galesville as formations and the Dresbach as a group.

⁵The Mt. Simon formation derives its name from typical exposures in a bluff on Mount Simon at Eau Claire, Wisconsin. Walcott, C. D., *Cambrian geology and paleontology: Smithsonian Misc. Coll.*, vol. 57, p. 354, 1914.

⁶The Eau Claire formation was named from the town of Eau Claire, Wisconsin, near which it is well exposed. Walcott, C. D., *Cambrian geology and paleontology: Smithsonian Misc. Coll.*, vol. 57, p. 354, 1914.

	Ft.
<i>Zone 3.</i> Dolomite, sandy, greenish-gray to gray, finely crystalline, locally argillaceous, containing shale and sandstone partings and beds; varies considerably in thickness	5-30
<i>Zone 2.</i> Sandstone, dolomitic, mostly pink, buff, and red, very glauconitic above the basal 40 to 50 feet; occurs in persistent beds very irregular in thickness, with green, red, and gray dolomitic silty shales, and gray, pink, and buff finely crystalline sandy generally glauconitic dolomite in beds that are probably lenticular.	225-250
<i>Zone 1.</i> Sandstone, gray, yellow, and buff, very fine- to coarse-grained, fossiliferous; individual grains covered with sooty black incrustations of finely divided pyrite; thickness very irregular	100-170

Thickness.—The Eau Claire formation averages 450 feet thick in wells to the northeast and is probably the same in north-central Illinois. The maximum known thickness in the region is in the Rabbit No. 1 well in the NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 31, T. 20 N., R. 10 E., Lee County, where it is 493 feet thick (pl. 28, No. 8). Assuming that its thickness varies in the same manner and degree as the overlying Cambrian formations, it is probably thickest, possibly more than 500 feet, in the north part of the Ottawa and Marseilles and the extreme south part of the Streator quadrangles.

Stratigraphic relations.—The Eau Claire formation is slightly disconformable on the Mt. Simon sandstone, and although the contact with the overlying Galesville sandstone is sharp and disconformable there is no evidence of an erosional break between the two in well cuttings.

Correlation.—The Eau Claire formation is correlated with the Eau Claire formation of Wisconsin on the basis of lithology and stratigraphic position.

GALESVILLE SANDSTONE⁷

Distribution.—The Galesville sandstone has been penetrated in a number of wells and is doubtless present throughout north-central Illinois.

Lithology.—The Galesville sandstone is composed almost entirely of white, buff, and light gray fine- to coarse-grained sandstone, some of which is dolomitic, with local thin beds or lenses of buff, light gray, brown, and pinkish sandy dolomite. The compactness of the formation varies with the amount of dolomite as cementing material, for at Peru and Oglesby and in Grundy and Livingston counties, where dolomite is abundant in the sandstone, the formation appears to be more compact than in the vicinity of Ottawa where dolomite is less abundant.

Thickness.—The maximum thickness of the formation recorded within the quadrangles is 215 feet at Ottawa, which is in an area in the north part of the Ottawa and Marseilles quadrangles where the sandstone is apparently thickest. The formation is thinnest in the south part of the Ottawa and Marseilles and the north part of the Streator quadrangles where it averages 125 feet thick (pl. 14).

Stratigraphic relations.—The Galesville sandstone is disconformable on the underlying Eau Claire formation. The contact of the Galesville and the overlying Franconia is gradational in many places.

Correlation.—On the basis of similarities in lithology and stratigraphic position, the Galesville sandstone of north-central Illinois is believed to be equivalent to the Galesville sandstone of Wisconsin.

FRANCONIA FORMATION⁸

Distribution.—The Franconia formation underlies all of north-central Illinois.

Lithology.—The Franconia formation consists of variegated fine-grained dolomitic very glauconitic compact sandstone, interbedded with greenish, gray, pink, and buff finely crystalline sandy glauconitic dolomites, and gray, green, and red sandy glauconitic shales. Locally at the base of the formation there are beds of buff to red coarse-grained dolomitic

⁷The Galesville sandstone was named for its typical occurrence in a bluff on Beaver Creek near Galesville, Wisconsin. Trowbridge, A. C., and Atwater, Gordon I., *Stratigraphic problems in the Upper Mississippi Valley*: Geol. Soc. America Bull., vol. 45, p. 45, Feb. 28, 1934.

⁸The Franconia formation was named from exposures near the town of Franconia, Minnesota. Berkey, C. P., *Geology of the St. Croix Dalles*: Am. Geol., vol. 20, p. 373, 1897.

TABLE 2.—POSITION AND THICKNESS OF GLAUCONITIC ZONES IN THE TREMPLEAU FORMATION IN WELLS
IN AND NEAR THE MARSEILLES, OTTAWA, AND STREATOR QUADRANGLES.

Company	Farm name and well No.	Location quarter section sec., T., R.	Zone One		Zone Two		Zone Three		Formation thickness (Feet)
			Distance above base	Thick- ness (Feet)	Distance above base	Thick- ness (Feet)	Distance above base	Thick- ness (Feet)	
Amboy Oil & Gas	McElroy No. 1	SW SW NW 30-20N-10E	At Base	50	75	5	...	..	150
E. Stevenson	Rabbit No. 1	NW SE SW 31-20N-10E	At Base	28	..	..	118	25	168
E. Stevenson	Minick No. 1	SW NW NE 16-19N-10E	At Base	25		No samples	upper part	..	175
Sewell Well	Peru City No. 5	NE NE NE 20-33N-1E	At Base	40	..	..	125	45	210
Layne North Central—Sewell Well	Oglesby City No. 2	NW NE NW 36-33N-1E	At Base	40	..	..	...	..	230
John Schomas	Ottawa Silica Company	NW SW NW 10-33N-3E	At Base	32	80	35	...	..	217
Layne North Central	Ottawa City No. 8A	NE NE SE 14-33N-3E			Glauconitic throughout		...	..	220
Layne North Central	Ottawa City No. 8	SW SW 1-33N-3E	At Base	15	55	45	155	30	225
J. P. Miller Artesian Well	Alton R. R. at Dwight	NE NW SW 9-30N-7E		..	..	..	170	67	260

sandstones which may be equivalent to the Iron-ton⁹ member of Wisconsin.

Thickness.—The Franconia formation averages between 150 and 175 feet in thickness. The maximum thickness thus far found represented by samples is 190 feet in the Ottawa City well No. 8B (app. C, 24). However, drillers' logs indicate that the formation thickens to the south and may be more than 200 feet thick in the south part of the Streator quadrangle.

Stratigraphic relations.—The Franconia formation is apparently conformable on the underlying Galesville sandstone, and its contact with the overlying Trempealeau formation is gradational.

Correlation.—The Franconia formation of north-central Illinois is correlated with the Franconia formation of Minnesota on the basis of lithology and stratigraphic position.

TREMPEALEAU FORMATION¹⁰

Distribution.—The Trempealeau formation doubtless underlies all of north-central Illinois. It lies directly beneath the glacial drift in the vicinity of Sandwich, DeKalb County (pl. 13).

Lithology.—The Trempealeau formation consists of gray, buff, and pinkish finely crystalline cherty locally sandy dolomite, with a few lenses of buff medium-grained dolomitic compact sandstone. It contains quartz geodes, particularly near the base, as fragments are frequently found in samples of well-cuttings.

Three more or less discontinuous glauconite zones are found in wells in and near north-central Illinois as shown in table 2.

Thickness.—The average thickness of the Trempealeau formation in north-central Illinois is 200 feet. It is greatest in the north part of the Ottawa and Mar-

seilles quadrangles, where it averages about 230 feet. The maximum thickness thus far penetrated in wells in the quadrangles is in the Ottawa city well No. 8B where it is 245 feet thick (app. C, 24). However, a total thickness of 260 feet was found in the Alton Railroad well at Dwight (app. C, 53).

Stratigraphic relations.—The Trempealeau formation is conformable with the underlying Franconia formation, the contact being one of gradation. It appears to be conformable also with the overlying Jordan formation wherever the latter is present, but along the Kankakee arch in southeastern DeKalb County the Trempealeau formation is probably overlain unconformably by the St. Peter sandstone.

Correlation.—The Trempealeau formation of Illinois is correlated with the Trempealeau formation of Wisconsin on the basis of similarities in lithology and stratigraphic position.

JORDAN FORMATION¹¹

Distribution.—The Jordan formation is believed to underlie all of the Marseilles, Ottawa, and Streator quadrangles, but north and northeast of them it is absent over the crest of the Kankakee arch. It is absent in the Sandwich village well No. 2 (app. C, 4), which is believed to be located almost on the crest of the arch, and there is also a pronounced thinning of the Jordan-Trempealeau-Franconia formations toward the axis of the Kankakee arch (pl. 16). In the vicinity of Batavia and Elgin in Kane County the Jordan is also absent, chiefly because of pre-St. Peter erosion.¹²

Lithology.—The Jordan formation in north-central Illinois consists dominantly

⁹The Iron-ton was named from the village of that name in Wisconsin. Ulrich, E. O., Notes on new names in the table of formations and the physical evidence of breaks between Paleozoic systems in Wisconsin: Wisconsin Acad. Sci. Trans., vol. 21, pp. 93-94, 1924.

¹⁰The name Trempealeau is derived from Trempealeau Bluff along Mississippi River in Wisconsin. Ulrich, E. O., Notes on new names in the table of formations and on physical evidence of breaks between Paleozoic systems in Wisconsin: Wisconsin Acad. Sci. Trans., vol. 21, pp. 79-90, 1924.

¹¹The Jordan formation was named for strata exposed in the town of Jordan, Scott County, Minnesota. Winchell, N. H., Geology of the Minnesota Valley: Geol. and Nat. Hist. Survey of Minnesota, Second Ann. Rept. for 1873, p. 149, 1874. In Wisconsin the Jordan is considered to be only a member of the Trempealeau formation (Twenhofel, W. H., Raasch, G. O., and Thwaites, F. T. Cambrian strata of Wisconsin: Geol. Soc. America Bull., vol. 46, no. 11, pp. 1709-1710, Nov. 30, 1935), but because of its magnitude and consistency and because of the marked stratigraphic break at its base the Illinois Survey classifies it as a formation.

¹²Gries, J. P., Subsurface geology of Barrington, Elgin, Geneva quadrangles: unpublished manuscript, Illinois Geol. Survey.

of dolomite with some interbedded shale and sandstone. The dolomite is sandy, cherty, white, pink, light gray, and green, and finely crystalline. Pink to buff sandy oölitic dolomite is found locally. The shale, when present, is dolomitic, varicolored, and sometimes micaceous. The sandstone, which is usually found in the basal part of the formation, is dolomitic, white and light gray, finely to coarsely granular, and mostly compact.

Thickness.—The maximum known thickness of the Jordan formation within the Marseilles, Ottawa, and Streator quadrangles is 53 feet, in the Ottawa Silica Company well (app. C, 26), and the minimum is 25 feet, in the R. N. Peddicord well north of Marseilles (app. C, 15), but in the surrounding area the formation ranges from 0 to 60 feet in thickness.

Stratigraphic relations.—The contact of the Jordan formation with the underlying Trempealeau formation is sometimes gradational, but in some localities it is quite sharp. Its contact with the overlying Oneota dolomite is one of distinct unconformity, as shown by rapid and large variations in thickness of the Jordan formation. There also may be locally a conglomerate at the base of the Oneota formation.

Within the Marseilles, Ottawa, and Streator quadrangles the Jordan formation is everywhere overlain by the Oneota formation, but northward in Kendall and DeKalb counties it is probably overlain with angular unconformity by the St. Peter sandstone along the Kankakee arch.

Correlation.—The Jordan formation of this region is correlated with the Jordan formation of Minnesota mainly on the basis of similar stratigraphic position, but there are also lithologic similarities.

ORDOVICIAN SYSTEM¹³

The Ordovician rocks of Illinois are divided into four series as follows: Prairie du Chien, represented by the Oneota, New Richmond, and Shakopee formations; the Chazyan, represented by the St. Peter sandstone; the Mohawkian, consisting of the Glenwood,¹⁴ Platteville, Decorah, and Galena formations; and the Cincinnati, represented by the Maquoketa shale. The maximum thickness of the Ordovician strata in this region is approximately 1200 feet.

PRAIRIE DU CHIEN SERIES¹⁵

ONEOTA DOLOMITE¹⁶

Distribution.—The Oneota formation is believed to underlie all of the Marseilles, Ottawa, and Streator quadrangles, but at Mendota in LaSalle County, at Plano in Kendall County, and at Morris in Grundy County (pl. 28, Nos. 3, 11, 17; app. C, 11, 17), the formation was deeply eroded in pre-St. Peter time, and along the crest of the Kankakee arch it is entirely absent (pls. 13, 17).

Lithology.—The Oneota formation consists of light gray, white, and buff, occasionally red and pink, finely to coarsely crystalline dolomite. Well-cuttings show considerable amounts of white and yellow generally oölitic chert, which probably occurs as lenses, nodules, and interbedded layers in the dolomite. The lithologic characters vary little over the entire area, but in some wells there is a basal conglomeratic-appearing layer of yellow, white, and pink chert mixed with sand and some clay.

Excluding the basal conglomeratic layer the formation can be divided into

¹³The name Ordovician was derived from Ordovices, the Roman name for a tribe of people that inhabited Wales where these rocks are typically exposed. Lapworth, C., On the Tripartite classification of the lower Paleozoic rocks: Geol. Mag., London, new series, vol. 6, pp. 12-14, 1879.

¹⁴The Glenwood was considered by some geologists to be of Chazyan age, but recent studies have shown it to be Mohawkian. For complete arguments see:

Stauffer, C. R., Conodonts of the Glenwood beds: Geol. Soc. America Bull., vol. 46, no. 1, pp. 125-168, Jan. 31, 1935.

Kay, G. Marshall, Ordovician System in the upper Mississippi Valley: Guidebook of Ninth Ann. Field Conference, Kansas Geol. Soc., pp. 285-286 and 288, 1935.

Elder, Stanley G., Stratigraphy of the Glenwood formation: unpublished manuscript, Illinois Geol. Survey.

¹⁵The Prairie du Chien was named from a series of exposures at Prairie du Chien, Crawford County, Wisconsin. Bain, H. F., Zinc and lead deposits of the upper Mississippi Valley: U. S. Geol. Survey Bull. 294, p. 18, 1906 (cites Lancaster-Mineral Point folio).

Grant, U. S., and Burchard, E. F., U. S. Geol. Survey Geol. Atlas Lancaster-Mineral Point folio (No. 145), p. 3, 1907.

¹⁶The name Oneota was derived from exposures along the Oneota (Upper Iowa) River in northeastern Iowa. McGee, W. J., Pleistocene history of northeastern Iowa: U. S. Geol. Survey Eleventh Ann. Report, pt. 1, p. 333, 1891.

three zones of variable thickness as follows:

	Ft.
<i>Zone 3.</i> Dolomite, cherty, white, light gray, and buff, finely crystalline, with the upper 20 to 50 feet sometimes sandy or containing sandstone lenses; chert is dense, oölitic, white and yellow.	110-210
<i>Zone 2.</i> Dolomite, cherty, glauconitic, partly sandy, white, light gray, buff, and pink, finely crystalline	5-25
<i>Zone 1.</i> Dolomite, cherty, slightly sandy, light gray, buff, pink-spotted, and chert, dense, oölitic, white and yellow.	20-50

Thickness.—The greatest thickness of the Oneota formation penetrated in the Marseilles, Ottawa, and Streator quadrangles is 265 feet in the R. N. Peddicord well near Marseilles (app. C, 15), and the minimum thickness of 130 feet is found in the Ottawa Silica Company well (app. C, 26). In the quadrangles the formation is thickest in a belt extending in a southwesterly direction through the central portion of the Marseilles, the south-central and southwestern parts of the Ottawa, and the northwestern part of the Streator quadrangles and is thinner in the northern part of the Ottawa, the northern and southern parts of the Marseilles, and most of the Streator quadrangles.

The thickness of the formation varies more outside of the quadrangles than within, as it is 365 feet thick (the maximum recorded thickness) in the Alton Railroad well at Dwight (app. C, 53), is only 117 feet thick in the Mendota city well (app. C, 11), and is absent in the Sandwich village wells (app. C, 4) and in an area in the vicinity of Sandwich (pls. 13, 17). The formation thickens in two zones, one three to eight miles wide trending southwest from the northwest corner of Grundy County to the southwest corner of LaSalle County, and the other in east Livingston County (pl. 17).

Stratigraphic relations.—The Oneota dolomite rests unconformably on the Jordan formation.

Where the Oneota formation is overlain by the New Richmond sandstone in normal sequence, the two formations are apparently conformable, but a major unconformity above the Oneota formation occurs in eastern Livingston and in southern Kendall, DeKalb, and Lee counties and northern LaSalle County

where it is succeeded directly by the St. Peter sandstone (pls. 13, 17, 18, 20, 21), all of the New Richmond and Shakopee formations and part of the Oneota formation having been removed by pre-St. Peter erosion.

Correlation.—The Oneota formation in north-central Illinois is correlated with the Oneota formation of Iowa on the basis of similar lithology and stratigraphic position.

NEW RICHMOND FORMATION¹⁷

Distribution.—The New Richmond formation is present in the Marseilles, Ottawa, and Streator quadrangles but is absent over the higher part of the Kankakee arch in DeKalb, Kendall, and Lee counties and in northern LaSalle County and also along deep pre-St. Peter channels in Grundy and southeastern Livingston (pl. 18) counties. It crops out more or less continuously along Fox River south of Sheridan, from about the center of sec. 5 to the NE. corner of sec. 18, T. 35 N., R. 5 E., LaSalle County.

Lithology.—The New Richmond formation consists dominantly of white or light gray to buff, fine- to coarse-grained, partly dolomitic, generally incoherent and porous sandstone, containing some white siliceous oölitic. In the western part of the region the sandstone is dolomitic, particularly in the lower 30 to 40 feet. At or near the base of the formation in the western part of the Ottawa quadrangle there is a fairly persistent horizon of sandy, usually cherty, light gray to buff dolomite. Eastward this zone appears to grade into a zone of white dolomitic sandstone.

In some wells the basal part of the formation is red, blue, and gray shale.

Thickness.—According to available information the New Richmond sandstone attains its greatest thickness in the vicinity of LaSalle, where a number of wells penetrated more than 160 feet of the formation. The maximum recorded thickness is 190 feet (app. C, 30), in a well at Starved Rock Park. The formation is thinnest in a belt about 10 miles wide

¹⁷The New Richmond formation is named from exposures in the vicinity of the village of New Richmond, St. Croix County, Wisconsin. Wooster, L. C., *Geology of the lower St. Croix district: Geology of Wisconsin*, vol. 4 p. 106, 1882.

running southwest from Kendall County. Between this belt and the truncation of the formation along the Kankakee arch in northern LaSalle County on the one side and the pre-St. Peter channels in Livingston and Grundy counties on the other side are belts in which the formation is thicker (pls. 18, 21).

Stratigraphic relations.—The New Richmond formation appears to be conformable both on the Oneota dolomite below and with the Shakopee formation which overlies it in normal sequence. However, a major unconformity occurs above the New Richmond sandstone along the southwest limb of the Kankakee arch in LaSalle and Kendall counties and along narrow strips in Grundy and Livingston counties where pre-St. Peter erosion removed the Shakopee formation, so that the New Richmond formation is overlain directly by the St. Peter sandstone.

Correlation.—The New Richmond of north-central Illinois is believed to be the stratigraphic equivalent of the sandstone that crops out in the vicinity of the village of New Richmond, Wisconsin.

SHAKOPEE FORMATION¹⁸

Distribution.—The Shakopee formation underlies all of the Marseilles, Ottawa, and Streator quadrangles but is absent over the Kankakee arch and along pre-St. Peter channels in Grundy and Livingston county (pl. 20). Outcrops of the Shakopee are found along Fox River from the center of the W. $\frac{1}{2}$ sec. 8 to about the center of sec. 18, T. 35 N., R. 5 E.,

Kendall County, and along Illinois and Little Vermilion rivers and their tributaries north and east of LaSalle¹⁹ (pl. 13). It also occurs below a thin cover of gravel and sand in the bed of Illinois River at Starved Rock in the Ottawa quadrangle and directly underlies glacial drift in the north part of the Marseilles quadrangle. Other outcrops of strata that may be Shakopee occur along Fox Valley near Millington (1) in and around Brodie's quarry in the SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 19, T. 36 N., R. 6 E., Kendall County; (2) in an old quarry in the NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 30, T. 36 N., R. 6 E., Kendall County; and (3) along the Chicago, Burlington and Quincy Railroad, in an adjacent old quarry, and along the river bluffs in the north-central part of sec. 36, T. 36 N., R. 5 E., LaSalle County (pl. 13).

Lithology.—The Shakopee formation is composed of dolomite with lenses or thin beds of sandstone and shale. The amount of clastic material in the formation is greater in the north and east parts than in the central, south, and west parts of the region. In the vicinity of Marseilles, well-cuttings of the Shakopee formation contain as much as 25 per cent of sandstone and shale.

The dolomite is buff to light brown and gray, finely to medium crystalline, generally sandy, and contains oölitic white chert. Locally, red silty argillaceous dolomite occurs in a horizon 75 feet above the base. The sandstones are dolomitic, light gray, buff and white, fine- to coarse-grained, and compact. Occasionally there are layers of dolomitic gray shale.

Thickness.—The regional variation in thickness of the Shakopee formation is the same as that of the New Richmond sandstone. The formation is thinnest in a belt about ten miles wide extending southwest from Kendall County. Between this belt and the truncation of the formation along the Kankakee arch in northern LaSalle County on the one side and the pre-St. Peter channels in Livingston and Grundy counties on the other are belts in which the formation is thicker (pl. 20). The maximum recorded thickness is 226 feet in the well at Chenoa (pl. 28, No. 56).

¹⁸The Shakopee formation derives its name from exposures near the village of Shakopee, Scott County, Minnesota. Winchell, N. H., Geol. and Nat. Hist. Survey of Minnesota, Second Ann. Rep. for 1873, p. 138-139, 1874.

Some geologists contend that the name Shakopee should not be used for this formation, as they believe that the strata at Shakopee are of Oneota age and they propose that Willow River, another name applied to the same beds, (Wooster, L. C., Geology of the Lower St. Croix District: Geol. Wisconsin, vol. 4, p. 106, 1882) be substituted. (Trowbridge, A. C., and Atwater, G. I., Stratigraphic problems in the Upper Mississippi Valley: Geol. Soc. America Bull., vol. 45, pp. 65-73, 1934.) Even if the strata at Shakopee are Oneota, which has not been established, the question remains as to whether the name Shakopee is still not valid because of its long usage and application to a formation whose identity and stratigraphic position were established and recognized elsewhere when the name was proposed.

Other papers on this subject are:

Couser, C. W., Paleozoic stratigraphy and structure in the Minnesota River Valley: Geol. Soc. America Proceedings for 1933, Abst., p. 383, 1934.

Powers, Elliot H., Stratigraphy of the Prairie du Chien: Guidebook of Ninth Annual Field Conference, Kansas Geol. Soc., p. 390, 1935.

Stauffer, C. R., Type Paleozoic sections in the Minnesota Valley: Jour. Geology, vol. 42, pp. 347-352, 1934.

Stauffer, C. R., et al., Guidebook of Ninth Annual Field Conference, Kansas Geol. Soc., pp. 171-173, 1935.

¹⁹Cady, G. H., Geology and Mineral Resources of the Hennepin and LaSalle Quadrangles: Illinois Geol. Survey Bull. 37, pp. 35-36, pls. 1, II, 1919.

Stratigraphic relations.—The Shakopee dolomite is underlain conformably by the New Richmond sandstone and is succeeded unconformably by the St. Peter sandstone. Erosion preceding the deposition of the St. Peter formation developed a very uneven surface on the Shakopee formation which may be seen in outcrops near Utica and Dixon²⁰ and is indicated elsewhere by the large local variations in the thickness of the Shakopee formation, as revealed by wells. Narrow belts in which the formation is very thin or absent appear to be pre-St. Peter stream channels.

Correlation.—The Shakopee formation of north-central Illinois is correlated with the Shakopee formation of Minnesota on the basis of similarity of lithology and stratigraphic position.

CHAZYAN SERIES²¹

ST. PETER FORMATION²²

Distribution.—The St. Peter sandstone underlies all of the Marseilles, Ottawa, and Streator quadrangles except (1) a small area of the Illinois River floodplain near Starved Rock in the Ottawa quadrangle where the sandstone has been completely eroded and the Shakopee dolomite underlies the river deposits (pls. 13, 21) and (2) two small areas along the north edge of the Marseilles quadrangle. These two exceptions are parts of larger areas where the St. Peter formation is absent on the LaSalle and Kankakee anticlines.

Numerous exposures of the St. Peter occur in the Ottawa and Marseilles quadrangles (pls. 1, 2, 11, and p. 71) and also in the vicinity of LaSalle.²³

Lithology.—The St. Peter formation is a white to light gray and buff fine- to coarse-grained friable sandstone (p. 73). Locally the basal few feet, called by well

drillers the St. Peter "cave", consists mainly of variegated sandy partly dolomitic shales, containing pebbles of yellow, white, and red partly oölitic chert ranging in size up to 4 mm., with some beds of buff conglomeratic sandstone. This basal zone is thicker in the eastern part of the area, where pre-St. Peter erosion seems to have been greater, than in the western and central portions of the region. It crops out a short distance west of the Ottawa quadrangle.²⁴

Thickness.—The St. Peter formation varies greatly in thickness (pl. 21). Its variations of greatest magnitude, such as the maximum reported thickness of 578 feet in the Morris City well No. 4 (app. C, 17) as compared with thicknesses 200 to 400 feet less in other wells nearest to it, are interpreted as the result of filling in pre-St. Peter river channels, but its more numerous local variations of lesser magnitude result from post-St. Peter erosion, some of it pre-Platteville, much of it pre-Pennsylvanian, and a considerable amount of it pre-Pleistocene, depending on which formation overlies it.

Stratigraphic relations.—The St. Peter sandstone lies unconformably on the Shakopee dolomite in the Marseilles, Ottawa, and Streator quadrangles, but to the north and east it lies directly on successively lower strata down to the Trempealeau formation.

Its contact with overlying strata is also unconformable. In extreme western and southern LaSalle, most of Lee, and all of Bureau, Putnam, Marshall, Woodford, and Livingston and southern Grundy counties, it is regularly succeeded by the Glenwood formation, but from the study of outcrops it has been determined that it is directly succeeded by the Pecatonica (basal) member of the Platteville formation at three localities—(1) sec. 35, T. 35 N., R. 1 E., at Troy Grove, (2) in the N. $\frac{1}{2}$ sec. 27, T. 34 N., R. 1 E., four miles north of LaSalle, and (3) in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 31, T. 33 N., R. 2 E., at Deer Park—showing the absence of the Glenwood formation at these places. Farther east, in secs. 21 and 22, T. 33 N., R. 2 E., in Starved Rock State Park and in secs. 16, 21, and 27, T. 33 N., R. 3 E., the St. Peter sandstone is directly over-

²⁰Cady, G. H., op. cit., p. 36.

Knappen, R. S. Geology and mineral resources of the Dixon Quadrangle: Illinois Geol. Survey Bull. 49, pp. 47-48, 1926.

²¹The Chazyan series was named from the Chazy limestone group of eastern New York. Grabau, A. W., Physical and faunal evolution of North America during Ordovician, Silurian, and early Devonian time: Jour. Geology vol. 17, pp. 209-252, 1909.

²²St. Peter is the name applied to the sandstone that crops out along Minnesota (St. Peter's) River, Minnesota. Owen, D. D., Report of a geological reconnaissance of the Chippewa land district of Wisconsin and the northern part of Iowa: U. S. 30th Congr., 1st sess., Sen. Exec. Doc. 57, pp. 27-31, 1848.

²³Cady, G. H., op. cit., pls. I, II.

²⁴Cady, G. H., op. cit., pp. 37 and 39.

lain by the Mifflin member of the Platteville formation,²⁵ revealing that not only the Glenwood formation but also the Pecatonica member of the Platteville are absent. This shows a successive overlap by the Platteville formation on the St. Peter from west to east.

Along Illinois Valley and the valley of Covell Creek near Ottawa, channels in the top of the St. Peter as much as 20 feet deep and nearly a mile wide are filled with Platteville limestone (pl. 13). These depressions are believed to be remnants of pre-Platteville valleys which trend north-south as indicated by the alignment of Platteville outliers southwest of Ottawa (pls. 13, 28). Similar pre-Platteville channeling is indicated by the extreme irregularity of the St. Peter surface in LaSalle County east of Marseilles and in northwestern Grundy County in the vicinity of Morris (pl. 22), where it is overlain by the Galena-Platteville formations.

In the central and southwest parts and along the northern border of the Ottawa and in most of the west and central parts of the Marseilles quadrangles (pl. 13) the St. Peter sandstone is in direct contact with Pennsylvanian strata, all of the intervening strata having been removed by pre-Pennsylvanian erosion which also developed on the St. Peter sandstone a very irregular surface of relatively low relief. In the north and northwest parts of the Ottawa and Marseilles quadrangles and in southwestern Kendall, northern LaSalle, and in southeastern Lee Counties, the St. Peter sandstone is directly succeeded by Pleistocene formations (pl. 13) and in these areas it has a very irregular surface developed by pre-glacial erosion.

Correlation.—The St. Peter sandstone of north-central Illinois is correlated with the type section in Minnesota on the basis of similarities in lithology and stratigraphic position.

²⁵Templeton, J. S., personal communication.

^{25a}The Mohawkian derives its name from a series of rocks exposed along the Mohawk River in New York. Clarke, J. M. and Schuchert, C., The nomenclature of the New York series of geological formations: Sci. n.s., vol. 10, pp. 876-877, 1899.

²⁶The Glenwood was named from exposures at Glenwood, Winneshiek County, Iowa. Calvin, Samuel, Geology of Winneshiek County: Iowa Geol. Survey, vol. 16, pp. 60-61 and 74-75, 1906.

MOHAWKIAN SERIES^{25a}

GLENWOOD FORMATION²⁶

Distribution.—The Glenwood formation is apparently present in all of the region except the north-central part, which includes all of the Marseilles and Ottawa and the north part of the Streator quadrangles. Wherever the St. Peter and older formations lie directly under Pennsylvanian strata or glacial till (pl. 13) the absence of the Glenwood formation could be ascribed to pre-Pennsylvanian or pre-glacial erosion, but the overlap of successively younger Platteville strata on the St. Peter sandstone (p. 61) in the vicinity of Illinois River from LaSalle to Marseilles is evidence that in that area the Glenwood formation was never deposited.

Lithology.—The Glenwood consists normally of an upward succession of sandstone, shale, and dolomite. The sandstone, ranging in thickness from 0 to 73 feet, is partly dolomitic, white, buff, and gray, fine- and coarse-grained, with occasional lenses of shale or dolomite or both, especially where it is exceptionally thick. The shale overlying the sandstone is sandy, somewhat dolomitic, and brown, green, and gray. It is rarely more than 10 feet thick and is frequently absent. The dolomite is gray, brown, buff, and green, very finely crystalline, and compact. The dolomite of the Glenwood formation is distinguishable from the basal sandy dolomite of the overlying Platteville formation in that it is argillaceous and has an earthy appearance, whereas the basal Platteville is not argillaceous and has a sugary appearance.

The sandstone of the Glenwood formation is distinguishable from the underlying St. Peter sandstone because it has a larger percentage of finer material and a distinct break in grade size from fine to coarse. It also has a relatively large proportion of garnet in contrast to the rare occurrence of garnet in the St. Peter formation.²⁷

The heavy minerals most abundant in the Glenwood sandstone are garnet, tourmaline, and zircon. Rutile, ilmenite, epidote, zoisite, hornblende, chlorite,

²⁷Thiel, Geo. A., Petrographic analysis of the Glenwood beds of southeastern Minnesota: Geol. Soc. America Bull., vol. 48, No. 1, p. 119, 1937.

fluorite, biotite, muscovite, tremolite, ceylonite, anatase, sphene, staurolite, and corundum occur in smaller amounts.²⁸

The relatively large amount of garnet in the Glenwood sandstone in contrast to that in the St. Peter and the presence of fresh-appearing non-rounded quartz grains indicate weathering and erosion of crystalline rocks on the land surface bordering the Glenwood sea, with consequent contribution of garnet and quartz to the sediments.²⁹ The most logical source of materials was the pre-Cambrian shield which lay to the north. A large percentage of the coarse sand grains of the Glenwood was probably derived from the St. Peter sediments, either by reworking of the St. Peter sand on the sea-floor or by addition of the sand from St. Peter sediments then exposed to erosion.

Thickness.—In drillers' logs the Glenwood is usually not separable from the St. Peter sandstone, so its thickness may be determined only from the records of the few wells from which samples of cuttings have been preserved and studied. The Glenwood is usually about 15 feet thick but is 80 feet thick in southeastern Lee County and 100 feet thick at Gardner in Grundy County (app. C, 7, 42; pl. 28, No. 8).

Stratigraphic relations.—Recent studies have shown the Glenwood formation to be unconformable on the underlying St. Peter formation.³⁰ This view is supported by the overlap of the Glenwood and Platteville beds on the St. Peter sandstone (p. 61). The contact of the Glenwood with the overlying Platteville is sharp, although the basal Platteville beds usually contain some sand.

Correlation.—The Glenwood formation in north-central Illinois is correlated with the Glenwood formation of Iowa on the basis of similarity in lithology and stratigraphic position. The Iowa Glenwood is correlated with the Lowville of the New York section.³¹

²⁸Thiel, Geo. A., op. cit. pp. 117-121.

Tyler, S. A., Heavy minerals of the St. Peter sandstone in Wisconsin: Jour. Sedimentary Petrology, vol. 6, pp. 55-84, 1936.

²⁹Elder, Stanley G., Stratigraphy of the Glenwood formation: Illinois Geol. Survey, unpublished ms.

³⁰Elder, Stanley G., op. cit.

³¹Kay, G. M., The Ordovician system in the Mississippi Valley: Guidebook of the 9th Ann. Field Conference Kansas Geol. Soc., p. 288, 1935.

PLATTEVILLE FORMATION³²

The Platteville formation is divided into members which are, in ascending order, the Pecatonica, the Mifflin, the Magnolia, and the Spechts Ferry.³³ The separation into members, based on the study of well-cuttings, is difficult and uncertain, and therefore the Platteville in this report is discussed as a unit.

Distribution.—The Platteville formation underlies all of the region except an irregular area in the north-central part (pl. 13). It is present also in small outliers west and southwest of Ottawa in T. 33 N., R. 3 E., and in secs. 21, 22, and 29, T. 33 N., R. 2 E., and may possibly underlie the greater part of T. 33 N., R. 2 E., or be represented by numerous outliers in this part of the region. The boundary of the Galena-Platteville in this township and the next township east has been question-marked to indicate the uncertainty of mapping, owing to lack of data (pl. 13).

Strata belonging to the Pecatonica member are found (1) at Troy Grove in sec. 35, T. 35 N., R. 1 E., (2) in the N. $\frac{1}{2}$ sec. 27, T. 34 N., R. 1 E., four miles north of LaSalle, and (3) at Deer Park in the NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 31, T. 33 N., R. 2 E. Strata belonging to the Mifflin member are found (1) in secs. 21 and 22, T. 33 N., R. 2 E., at Starved Rock State Park, (2) in secs. 16, 21, and 27, T. 33 N., R. 3 E., and (3) at Deer Park. No strata belonging to the Magnolia and Spechts Ferry members have been recognized in outcrops, although these members are doubtless present in parts of the region where the Platteville attains its full thickness.³⁴

³²The Platteville formation was named from typical exposures near the town of Platteville, Wisconsin. Bain, H. F., Zinc and lead deposits of northwestern Illinois: U. S. Geol. Survey Bull. 246, p. 19, 1905.

³³The Pecatonica was named from exposures along the Pecatonica valley, Wisconsin. Hershey, O. H., The Elk Horn Creek area of sandstone: Am. Geologist, vol. 14, p. 175, 1894.

The Mifflin derives its name from outcrops in the east edge of Mifflin, Iowa County, Wisconsin. Bays, C. A., Stratigraphy of the Platteville formation: Unpublished Ph.D. thesis, Univ. of Wisconsin, 1937.

The Magnolia member was named from exposures one mile south of Magnolia, Rock County, Wisconsin. Bays, C. A., and Raasch, G. O., Mohawkian relations in Wisconsin: Guidebook of the 9th Ann. Field Conference Kansas Geol. Soc., p. 298, 1935.

The Spechts Ferry member was named from exposures in a ravine near Spechts Ferry, Dubuque County, Iowa. Kay, G. M., Divisions of the Decorah formation: Science, vol. 67, p. 16, 1928.

³⁴Templeton, J. S., personal communication.

Lithology.—The Platteville formation consists of brown, buff, and gray very finely crystalline compact dolomite and fossiliferous brown and gray very finely granular to lithographic dolomitic limestone, which in well-cuttings have a characteristic mottled appearance. At various horizons, but chiefly in the upper part of the formation, there are lenses, nodules, and beds of brown, gray, and white, translucent to opaque, somewhat chalcedonic chert. The lower 5 to 15 feet of the formation consists of brown very finely crystalline sandy dolomite or dolomitic limestone.

The distribution of the dolomite or limestone is related not stratigraphically to horizons in the formation but geographically to the major structures. The dolomite content increases toward the crests of the LaSalle anticline, the Kankakee and Wisconsin arches, and other anticlines, and the formation may be almost entirely dolomite on some of the higher parts of these structures. The limestone and dolomite areas are not sharply separated but grade one into the other.

The characters that distinguish the Platteville from the overlying Decorah and Galena formations in well-cuttings in this region are (1) the very finely crystalline or granular or lithographic texture, (2) the usually mottled color, (3) the compactness of the formation where it is a dolomite, and (4) the general absence of shaly partings.

Thickness.—As the Galena, Decorah, and Platteville formations are not separable in drillers' logs, their combined thickness is shown on one map (pl. 23). However, they can be distinguished by studies of well-cuttings which are available for 23 wells in the region, and from these some idea of the thickness of each formation may be obtained. The Platteville probably attains thicknesses of between 125 and 140 feet along the eastern and southern borders of the Marseilles quadrangle and over most of the Streator quadrangle. The greatest thickness so far obtained in drilling within the region was 180 feet in the village of Fairbury well No. 3 (app. C, 57). Disregarding small local variations in thickness the formation thickens progressively from north to

south at a rate of about 0.9 foot per mile and also from west to east although not nearly as rapidly.

Stratigraphic relations.—The Platteville formation is underlain with apparent conformity in parts of the region by the Glenwood formation and unconformably by the St. Peter sandstone in other parts (p. 61).

The contact of the Platteville and the overlying Decorah formations is usually gradational and very difficult to determine. However, in the south part of the Ottawa and Marseilles quadrangles and in west and central Grundy County the Platteville formation is overlain unconformably by Pennsylvanian strata. Where the Platteville-Pennsylvanian unconformity is exposed, in the vicinity of Ottawa, it has a relief of only about 5 feet, but from records of wells it is evident that elsewhere the relief is much greater (pls. 23 and 24).

The Platteville formation is covered directly by glacial deposits in parts of all three quadrangles (pl. 13) and in northern Grundy, southeastern Kendall, northwestern LaSalle, and part of southeastern Lee counties.

Correlation.—On the basis of lithology, fossil content (app. G, table 1), and stratigraphic position the Platteville formation of this region is correlated with the Platteville formation of Wisconsin. The Spechts Ferry member has been correlated with the so-called "Decorah shale" of Missouri, and the lower beds have been correlated with the upper Plattin beds of Missouri.³⁵

DECORAH FORMATION³⁶

The Decorah formation consists of two members, the Ion and Guttenberg, but it is not possible to separate these members in well-cuttings, so it is considered as a single unit.

Distribution.—The Decorah formation is present in all of the region except the north-central part. It underlies glacial drift or Pennsylvanian strata in a narrow

³⁵Kay, G. M., The Ordovician system in the Upper Mississippi Valley: Guidebook of the 9th Ann. Field Conference Kansas Geol. Soc., p. 288, 1935.

³⁶The Decorah formation was named from exposures at the village of Decorah, Winneshiek County, Iowa. Calvin, Samuel, op. cit., pp. 60-61, 84-85.

belt that probably coincides roughly with the 125-foot contour on the Galena-Platteville isopach map (pl. 23), as the thickness of the Platteville averages between 120 and 150 feet.

Lithology.—Brown, gray, buff, and purplish cherty, usually argillaceous dolomite or limestone with thin partings of gray, brown, and purplish brittle fossiliferous calcareous shale makes up the Decorah formation. The distinctive features of the strata as exhibited in well-cuttings are the presence of (1) black, gray, dark brown specks and flakes in the limestone or dolomite, giving it a peculiar speckled appearance, (2) scolecodonts or conodonts, sometimes well preserved but more often fragmentary, (3) shaly surfaces and pits in the cuttings, and (4) speckled, partly sandy gray, brown, and white translucent chert.

In samples from three wells in the eastern part of the region, a semi-oolitic to oolitic, brown to buff, lithographic to very finely granular limestone occurs near and at the top of the formation (app. C, 18, 43). This zone has not been found in wells to the west. The oolites seem to be the result of chemical or biochemical precipitation rather than of mechanical wear, as they consist of concentric rings of calcareous material around a nucleus of silt or very fine sand.

Thickness.—In the south and west parts of the Streator quadrangle the Decorah formation is from 40 to 50 feet thick, whereas in the east and south parts of the Marseilles quadrangle it is only 20 to 30 feet thick. A comparison of sample-study logs in the region indicates a progressive thickening to the south and east similar to that found in the Platteville formation.

Stratigraphic relations.—The Decorah formation is probably underlain conformably by the Platteville formation throughout the entire region, and in the greater part of the region it is overlain conformably by the Galena limestone or dolomite. However, in the belt where it underlies glacial drift or Pennsylvanian strata, as a result of pre-Pennsylvanian or preglacial erosion or both, it is overlain unconformably by those deposits.

Correlation.—The Decorah of north-central Illinois is correlated with the Decorah formation of northern Illinois and of the type section in Iowa on the basis of fossil content (app. G, table 1), lithology, and stratigraphic position. The Decorah formation of Iowa has been correlated³⁷ with the lower Trenton beds of New York.³⁸

GALENA FORMATION³⁹

The Galena formation consists of three members which are, in ascending order, the Prosser, the Stewartville, and the Dubuque, but they cannot be satisfactorily distinguished in well logs, so the formation is herein treated as a single unit.

Distribution.—The Galena formation is present in all of the region except the north-central part. Its lower boundary lies between the 150- and 175-foot contour on the Galena-Platteville isopach map (pl. 23).

Lithology.—The Galena formation is often referred to as the Galena dolomite, which is erroneous as the formation may be partly or entirely limestone. It is composed of brown to buff, medium to coarsely crystalline partly cherty dolomite or dolomitic limestone. Where it is weathered the formation has a mottled or light yellow color. The dolomite contains numerous vesicles frequently lined with clear crystals of calcite. The limestone contains dispersed crystals of dolomite, mostly less than 0.1 mm. in diameter. Occasionally sand grains are found in the upper half of the formation. The distribution of limestone and dolomite in the Galena formation is related geographically to major structures in the same manner as it was in the Platteville formation (p. 64).

The chert usually occurs in the lower half or third of the formation although it is often present in varying amounts throughout the entire formation. It is white to brown and gray, usually trans-

³⁷Kay, G. M., op. cit. pp. 289-290.

³⁸Bays, C. A., and Raasch, G. O., Mohawkian relations in Wisconsin: Guidebook of 9th Ann. Field Conference Kansas Geol. Soc., pp. 299-301, 1935.

³⁹The Galena formation derives its name from the fact that most of the galena mined from the upper Mississippi Valley was found in it. Foster, J. W., and Whitney, J. D., Geology of the Lake Superior land district, Part II: 32nd Cong. Spec. Sess., Sen. Ex. Doc. 4, p. 146, 1851.

lucent, and frequently contains vesicles lined with clear quartz crystals.

The larger crystal or grain size and the greater porosity of the Galena distinguish it from the underlying Decorah and Platteville formations.

Thickness.—Where the Galena formation is overlain by the Maquoketa shale in normal sequence its thickness is between 180 and 200 feet, but where the formation has suffered pre-Pennsylvanian and later erosion and is succeeded by Pennsylvanian or Pleistocene strata (pls. 13, 28, 29), its thickness is highly variable.

Stratigraphic relations.—The Galena formation is underlain conformably by the Decorah formation. Its contact with the overlying Maquoketa formation is one of slight disconformity. However, in much of north-central Illinois it is overlain unconformably by Pennsylvanian or Pleistocene beds (pls. 28, 29) as a result of pre-Pennsylvanian or preglacial erosion or both. In the eastern part of the Marseilles quadrangle and near Morris the upper surface of the Galena is deeply channelled as a result of this erosion and has a maximum relief of about 100 feet.

Correlation.—The Galena formation of this region is correlated with the Galena formation of northwestern Illinois and Wisconsin on the basis of similarity in lithology, fossil content (app. G, table 1), and stratigraphic position. The Prosser member makes up most of the Galena formation in the Upper Mississippi Valley.⁴⁰ The Galena formation of Wisconsin is correlated with the Trenton of New York and the Kimmswick of Missouri.⁴¹

CINCINNATIAN SERIES⁴²

MAQUOKETA FORMATION⁴³

Distribution.—The Maquoketa formation is present along the east edge and in the south and the west parts of north-

central Illinois. It is absent from all of the quadrangles except the extreme south part of the Streator quadrangle (pls. 13, 25).

Lithology.—The Maquoketa formation consists of dolomitic shale and argillaceous dolomite or limestone. Three members are distinguishable,⁴⁴ as follows:

	Thickness Ft.
3. Upper green shale member	40-90
2. Middle limestone or dolomite and shale member	50-120
1. Lower brown shale member	25-45

The lower member is composed of firm thick-bedded dark brown, occasionally gray or brownish-gray, calcareous or dolomitic shale, locally grading to dark brown very argillaceous limestone. Locally it is very fossiliferous with the majority of the fossils representing bryozoan remains.

The middle member consists dominantly of brown to gray fine- to coarse-grained limestone or dolomite, with some interbedded fossiliferous brownish-gray to drab calcareous or dolomitic shale. The limestone usually has a speckled appearance and contains abundant fragments of bryozoans, crinoids, corals, and brachiopods. The interbedded shale is also quite fossiliferous, the fossils being mostly bryozoan fragments.

The upper member consists of green, greenish-gray, and gray partly silty dolomitic or calcareous shale, with occasional lenses of compact, very finely crystalline, greenish-gray to gray, very argillaceous dolomite or limestone.

Thickness.—The Maquoketa formation is usually between 150 and 170 feet thick but 200 feet of it was penetrated in the Ladd village well in eastern Bureau County, and 195 feet in the Rabbit well No. 1 in southeastern Lee County (pl. 28, No. 8).

Stratigraphic relations.—The Maquoketa formation is underlain with slight disconformity by the Galena formation.

⁴⁰Bays, C. A., and Raasch, G. O., op. cit. p. 300.

⁴¹Kay, G. M., op. cit. pp. 290-293.

⁴²The Cincinnati series derives its name from exposures in Ohio and Kentucky in the vicinity of Cincinnati. Meek, F. B., and Worthen, A. H., Acad. Nat. Sci. Philadelphia Proc., vol. 17, p. 155, 1865.

⁴³The Maquoketa formation was named for exposures along Little Maquoketa River, Dubuque County, Iowa. White, C. A., Geology of Iowa, vol. 1, p. 181, 1870.

⁴⁴Cady, G. H., Geology and mineral resources of the Hennepin-LaSalle quadrangles: Illinois Geol. Survey Bull. 37, pp. 45-46, 1919.

The contact of the Maquoketa formation with the normally overlying Silurian system is one of erosional unconformity with a probable erosion of as much as 70 feet of the Maquoketa (pl. 25). This amount of erosion is sufficient to remove most or all of the upper shale member of the Maquoketa formation, so that the dolomites of the Silurian may lie directly on the middle dolomite or limestone member of the formation. In such cases the Silurian and Maquoketa dolomites may not be distinguished in drillers' logs, with consequent errors in reported thicknesses of the respective formations.

In parts of the region, however (pls. 13, 28, 29), the Maquoketa formation is succeeded unconformably by Pennsylvanian or Pleistocene strata (pls. 28, 29). In such places the middle dolomite or limestone member may be the highest part of the formation and therefore may be erroneously designated as the Silurian dolomite by drillers.

Correlation.—The Maquoketa beds of north-central Illinois are correlated with the Maquoketa formation of Iowa on the basis of stratigraphic position and lithologic characters. The upper part of the Maquoketa formation of Illinois and Iowa has been correlated with the lower Richmond of Indiana and Ohio⁴⁶ or considered probably the equivalent of most of the Richmond.⁴⁷

In Iowa the Maquoketa formation is separated into four members, the Elgin, Clermont, Fort Atkinson, and Brainard, in ascending order,⁴⁵ but it is not possible to correlate these with the three recognized in north-central Illinois on the basis of available data.

⁴⁵Calvin, Samuel, op. cit. pp. 97-98.

⁴⁶Savage, T. E., Richmond rocks of Iowa and Illinois: *Am. Jour. Sci.*, 5th series, vol. 8, pp. 411-427, 1924.

⁴⁷Ladd, H. S., Stratigraphy and paleontology of the Maquoketa shale of Iowa, Part 1: *Iowa Geol. Survey*, vol. 34, p. 368, 1929.

Kay, G. M., The Ordovician system in the Upper Mississippi Valley: *Guidebook of the 9th Ann. Field Conference*, Kansas Geol. Soc., p. 295, 1935.

⁴⁸The name Silurian is derived from Silures, the Roman name for a tribe who formerly inhabited a region that now comprises parts of both England and Wales, where this system of rocks is typically exposed. Murchison, R. L., On the Silurian system of rocks: London and Edinburgh *Philos. Mag. and Jour. Sci.*, 3rd series, vol. 7, pp. 46-52, July 1835.

SILURIAN SYSTEM⁴⁸

The Silurian system in Illinois is composed of rocks of the Alexandrian or Lower Silurian series and Niagaran or Middle Silurian series, which are further divided into formations as shown in table 3. Rocks of Late Silurian or Cayugan age are not definitely known to occur in Illinois.

No Silurian bedrock is known to occur in the Marseilles, Ottawa, and Streator quadrangles, but it is found in wells west of the LaSalle anticline and in north-eastern Kendall, in extreme southeastern Grundy, and in Livingston and McLean counties (pls. 13, 27). Strata belonging to the Alexandrian series may occur in the southwest part of the Streator quadrangle.

The thickness of the Silurian system is shown on plate 27.

ALEXANDRIAN SERIES⁴⁹

The Alexandrian series crops out in northeastern, northwestern, and southwestern Illinois, where it is composed of the Orchard Creek, Girardeau, Edgewood, and Kankakee (Sexton Creek) formations, but as these are very difficult to distinguish in well-cuttings in the region, the series is considered as a unit in the following discussion.

Lithology.—The lower part of the Alexandrian series, possibly representing the Edgewood formation, consists of greenish-gray and green, dolomitic or calcareous, sandy siltstone, with some interbedded very finely crystalline silty sandy argillaceous dolomite, and greenish-gray and green dolomitic silty shale. The upper part of the series, possibly representing the Kankakee formation, is composed of

⁴⁹The name Alexandrian is derived from Alexander County, Illinois. The series was first proposed by Savage to include strata between the top of the Cincinnati and the base of the Brassfield limestone (Ohio Clinton). Later, when it was shown that the Brassfield was older than the Clinton of New York, Savage modified the definition to include all the strata between the top of the Cincinnati and the top of the Brassfield.

Savage, T. E., On the Lower Paleozoic stratigraphy of southwestern Illinois: *Am. Jour. Sci.*, 4th series, vol. 25, pp. 433-434, 1908.

Schuchert, Charles, Paleogeography of North America: *Geol. Soc. America Bull.*, vol. 20, p. 538, 1910.

Savage, T. E., Alexandrian series in Missouri and Illinois: *Geol. Soc. America Bull.*, vol. 24, p. 352, 1913.

TABLE 3.—PROVISIONAL CORRELATION OF SILURIAN STRATA IN
ILLINOIS AND ADJACENT STATES

System	Series		Illinois			Iowa	Missouri	Wisconsin		
			Southwestern	Northeastern	Northwestern					
Silurian	Niagaran	Lockport		Port Byron	Port Byron	Gower (in part)	Bainbridge			
				Racine	Racine			Racine (including Guelph)		
			Joliet	Waukesha Joliet	Waukesha Joliet	Hopkinton		Waukesha		
		Clinton								
			Alexandrian		Sexton Creek (Brassfield)	Kankakee (Brassfield)	Kankakee (Brassfield) ("Waucoma")	Waucoma	Brassfield	Byron
					Edgewood Bowling Green Cyrene	Edgewood Bowling Green Essex; Channahon	Edgewood ("Winston")	Edgewood	Edgewood	Mayville
		Noix oölite		Noix						
		Girardeau Orchard Creek								

Copied from Savage, T. E., Silurian rocks of Illinois: Geol. Soc. America Bull., vol. 37, pp. 513-534, 1926, with further subdivisions for various parts of Illinois according to same reference.

very finely crystalline buff to gray slightly cherty dolomite or dolomitic limestone.

Thickness.—The Alexandrian series appears to be consistently about 50 feet thick in wells where it can be more or less definitely distinguished. However, it is possible that in some of the wells the thickness is greater than this, as some of the beds ascribed to the Niagaran may belong to the Alexandrian series.

Stratigraphic relations.—The Alexandrian series is underlain unconformably by the Maquoketa formation. There is little or no break discernible between the Alexandrian and Niagaran series in north-central Illinois, but as the contact is disconformable between the two series elsewhere in the State the two are probably disconformable here.

Correlation.—The correlation of the Alexandrian rocks of Illinois with those of adjacent states is shown in table 3.

NIAGARAN SERIES⁵⁰

The Niagaran series of northern Illinois is divided into the Joliet, Waukesha, Racine, and Port Byron formations (table 3), but as it is difficult to distinguish the formations in well-cuttings, the series is discussed as a unit.

Distribution.—The Niagaran series is present only in the west and south part of the region and northeastern Kendall County (pls. 13, 27), and does not occur in the Marseilles, Ottawa, and Streator quadrangles. Limestone or dolomite occurring in the upper part of the Maquoketa formation where the Silurian system is absent (p. 67), especially in a large part of eastern Kendall County, is often erroneously recorded in drillers' logs as

⁵⁰This series derives its name from Niagara Falls where it is well developed. Hall, James, Report of the Survey of the fourth geological district: Natural History of New York, part 4, Geology of New York, vol. 4, p. 80, 1843.

"Niagaran lime" and this fact must be kept in mind in delimiting the extent of the Silurian in this region.

Lithology.—Compact to vesicular, finely crystalline light gray, white, and brownish-gray dolomites and dolomitic limestones comprise the Niagaran series. White to light gray dense chert indicative of the Waukesha formation usually occurs in the middle or upper portion of the series. In places the middle portion of the series contains scattered grains of very fine sand.

Thickness.—The Niagaran series has a maximum recorded thickness of 550 feet at Minonk.

Stratigraphic relations.—The Niagaran series is underlain with slight disconformity by the Alexandrian series. It is overlain unconformably by Pennsylvanian

strata except in the vicinity of the village of Henry, Marshall County, where it is succeeded unconformably by the Devonian system.

Correlation.—The correlation of the Niagaran formations of northern Illinois is shown in table 3.

DEVONIAN AND MISSISSIPPIAN SYSTEMS

Devonian strata are present in the western part of the region (pls. 13, 29) and Mississippian strata are certainly known to occur only in the extreme western portion of the region, where 77 feet of brownish-gray micaceous shale of early Mississippian age, containing *Sporangites huronense*, was penetrated in the Henry village well (app. C, 45).

SYSTEM, GROUP, OR FORMATION	GRAPHIC COLUMN	FEET MIN. MAX.
PLEISTOCENE S.		0 300
TERTIARY (?) S.		0 5
MC LEANSBORO G.		0 250
CARBONDALE G.		200
TRADEWATER G.		0 50
KINDERHOOK G.		0 77
DEVONIAN S.		0 35
PORT BYRON		
RACINE		
WAUKESHA		0 500
JOLIET		
KANKAKEE		0 60
EDGEWOOD		
MAQUOKETA		0 200
GALENA		0 200
STEWARTVILLE		
DUBUQUE		
PROSSER		
DECORAH		0 60
ION - GUTTENBURG		
PLATTEVILLE		0 180
SPECHTS FERRY		
MAGNOLIA		
MIFLIN		
PECATONICA		0 100
GLENWOOD		
ST. PETER		0 528
SHAKOPEE		0 226
NEW RICHMOND		0 190
ONEOTA		0 365
JORDAN		0 60
TREMPEALEAU		0 260
FRANCONIA		0 200
IRONTON ?		
GALESVILLE		100 215
EAU CLAIRE		350 500
MT. SIMON		1600 1750
PRE-CAMBRIAN		

FIG. 31.—Columnar section of the rocks of the Ottawa, Marseilles, and Streator quadrangles.

CHAPTER VI—STRUCTURAL GEOLOGY

BY
J. NORMAN PAYNE

GENERAL PRINCIPLES

Briefly, structural geology treats of the attitude of rock strata in place. As most of the bedrock strata were essentially horizontal when deposited, any existing departure from horizontality indicates that they were affected by some major earth movement after their deposition.

The structure of a rock stratum is determined by its *dip* or divergence from a horizontal plane, measured as so many degrees or as so many feet per mile in the direction of maximum divergence, and by its *strike*, the direction of the intersection of its surface with a horizontal plane, which is always at right angles to the direction of the dip.

The principal rock structures are *folds* and *faults*. Upward folds much longer than wide are called *anticlines* or *arches*; downfolds much longer than wide are called *synclines*; similar upfolds and downfolds relatively equidimensional are called respectively *domes* and *basins*. Beds dipping uniformly in one direction for a long distance form a *monocline*. Folds that have about the same dip on each side or *limb* are *symmetrical* and those of which one limb dips more steeply than the other are *asymmetrical*. The line along which folding apparently occurs is termed an *axis*. Slope along the axis is termed *plunge* or *pitch*. Appreciable movement of rock strata on one side of a joint or fracture with reference to those on the other side creates a *fault*. The *fault-plane* may be either *vertical* or *inclined*. If the beds on the upper side of an inclined fault-plane appear to have slipped down, presumably as a result of local stretching or lengthening of the earth's crust, the fault is a *normal* or *gravity* fault, but if they appear to have slipped or been pushed up

over those on the under side, the fault is called a *thrust* fault and implies a local shortening of the earth's crust.

Structures may be depicted by cross-sections, which show clearly the attitude of the rocks along a chosen line (pls. 28, 29) but do not show areal variations, or by structure contour-maps which are similar to topographic maps, except that the contours represent lines of equal elevation on the top of certain beds or formations instead of on the ground, and which therefore provide a complete areal representation of the structure of such beds or formations. The relative accuracy and detail of structure contour-maps is a function of the number and reliability of available datum points.

In regions where outcrops are abundant, the rock structures may be determined with considerable accuracy by actual measurements of the dip of the rocks at numerous points or by an accurate survey of the location and elevation of outcrops of key beds. But in most of Illinois, as in many other regions, outcrops are so few that records of wells and other borings provide most of the available structural data. The elevation of any key-bed reported in such records is easily ascertained by subtracting the depth to it from the surface elevation. As the number of borings to any formation naturally decreases with the depth at which it lies, structure maps of higher formations are more detailed and those of lower horizons are more generalized.

Because structure contour-maps are areal representations of recognizable bedrock surfaces, the approximate depth to such surfaces at any point on the maps is the difference between the elevations of the surface and of the ground at that point. The approximate depth to other

ter, and magnitude of various structural deformations, the direction and magnitude of the forces producing them, and the amount of erosion between different periods of deposition may be inferred.

Structure contour maps are especially valuable in areas where factors favorable for oil production exist, because they show the location and size of anticlinal areas, which constitute one of the most favorable sites for the accumulation of oil.

In the Marseilles, Ottawa, and Streator quadrangles most of the strata appear to lie horizontal, although at a few places they are tilted, but actually the apparently horizontal beds are inclined at low angles. For example, the beds in Starved Rock State Park appear to be perfectly horizontal, but along the south side of Illinois Valley the top of the St. Peter sandstone may be observed to descend gradually from near the top of the bluffs in the park eastward to the base of the valley-walls near Covell Creek.

As earth movements in the area occurred at more than one time during its geologic history, the various formations are not always parallel to each other. As each successive movement affected all the earlier formations, successively deeper formations are affected by more movements, as is shown by the series of formation-surface contour maps covering the region (pls. 15, 19, 22, 24, 26).

The data used in making the maps were derived almost entirely from records of borings of which the surface elevations were obtained by estimation from topographic maps, by transit and level, or by short hand-level traverses, so that the maximum possible error in elevation is 20 feet. Two major anticlinal structures—the LaSalle anticline and the Kankakee arch, several lesser anticlinal structures, and complementary major and lesser synclinal structures in the region (fig. 102) are revealed by the maps. Some of the structures were formed prior to the deposition of the St. Peter sandstone, so that they appear only in the older formations (pls. 15, 19; fig. 102); some of these suffered later movement, so that the degree of folding is different in the older and in the younger formations; and other structures did not originate until after St. Peter time,

so that they are of about equal magnitude in all formations. In some cases the axes of the structures are not exactly superposed in successive formations.

STRUCTURAL FEATURES

*LaSalle anticline.*¹—The most prominent structural feature of north-central Illinois is the LaSalle anticline, a broad step-fold or monocline having a maximum westward dip of approximately 2000 feet per mile and an eastward dip of less than 25 to 50 feet per mile on the higher formations. The dip of the formations below the Pennsylvanian is much greater than that of the Pennsylvanian strata, especially on the west limb (pls. 28, 29). The differential elevation measured between the deepest part of the Granville basin and the crest of the LaSalle anticline east of Oglesby is about 1700-1800 feet on the top of the St. Peter and the top of the Galesville formations (pls. 15, 22).

The axis of the LaSalle anticline in north-central Illinois area trends approximately S. 40° E. from eastern Lee County to about six miles north of Mendota, whence it swings in a broad arc south and southwest to a point about six miles north of LaSalle, thence continues S. 24° E. to about a mile east of Oglesby, where it abruptly changes to about S. 15° E., and continues in this direction to northern McLean County. From the north almost to LaSalle the crest of the anticline is relatively even, with a few low peaks and shallow sags, but from a little north of LaSalle the anticline plunges steadily southward.

The anticline constitutes the eastern boundary of the great regional structural depression known as the Illinois basin, whose principal axis roughly parallels that of the anticline. Disregarding the minor flexures in it, the portion of the basin in north-central Illinois pitches gently to the southeast.

*Kankakee arch.*²—The northeastern part of north-central Illinois is crossed by the

¹Cady, G. H., Structure of the LaSalle anticline: Illinois Geol. Survey Bull. 36, pp. 85-188, 1920.

²Eckblaw, George E., Kankakee arch in Illinois: Geol. Soc. America Bull., vol. 49, pp. 1425-1430, 1938; Illinois Geol. Survey Circular 30, 1938.

Kankakee arch, an asymmetrical anticline whose steeper limb is to the southwest and dips more than 100 feet per mile. The maximum differential elevation of the structure is probably between 1300 and 1500 feet (pl. 15, fig. 102).

The anticline trends about S. 40° E. through southeastern DeKalb, northeastern LaSalle, and southwestern Kendall counties and plunges to the southeast. It is traversed by at least one longitudinal fault of which the downthrow side is on the northeast.

Dwight anticline.—An apparently symmetrical anticline 25 to 30 miles east of and roughly parallel to the LaSalle anticline is herein named Dwight after the town of Dwight, Livingston County, which is situated approximately on the axis (pls. 22, 24, 26; fig. 102). Its maximum differential elevation is about 200 feet. From its northern terminus about six miles north of Marseilles its post-St. Peter axis trends S. 55° E. for a few miles, thence S. 30-35° E. to about six miles north of Dwight, thence almost due south to Sau-nemin, and thence, S. 25-30° E. to Chatsworth. Its pre-St. Peter axis trends almost due north along the west side of Grundy County nearly from Illinois River (fig. 102). The anticline plunges southward at the rate of about 15-20 feet to the mile.

Kempton syncline.—On the east side of the Dwight anticline there is a major structural depression for which the name Kempton is herein proposed after the town of Kempton, Ford County, which is situated approximately on its axis (pls. 22, 24, 26; fig. 102). The characteristics of this syncline have not been fully determined but it apparently extends laterally east as far as Buckingham, Kankakee County,³ its axis is approximately parallel to the south part of the Dwight anticline, it pitches southeasterly, and it is depressed several hundred feet below the crest of the Dwight anticline.

Oakdale syncline.—The Dwight anticline is limited on the west by a syncline, herein named Oakdale because the well at

Oakdale Women's Reformatory west of Dwight reveals the structure (pls. 22, 24, 26; fig. 102). The Oakdale syncline is a narrow shallow trough, trending about S. 35°-40° E. from north of Illinois Valley to a few miles northwest of Dwight, thence almost due south past the reformatory. It has a maximum depth of about 50 feet below the crests of the bordering anticlines and pitches gently southward.

Odell anticline.—The Oakdale syncline is limited on the west by a broad anticline, herein named Odell after the town of Odell, Livingston County, which is situated on the axis (pls. 15, 19, 22, 24, 26; fig. 102). The axis of the anticline is roughly parallel to and 15-20 miles east of the LaSalle anticline. It trends S. 10° E. from about five miles northwest of Sheridan to about three miles north of Marseilles, thence about S. 25-15° E. from Fox River through Marseilles to Odell, whence it trends almost due south to Fairbury. The anticline is slightly asymmetrical, the east limb being somewhat steeper than the west limb. Its maximum differential elevation where best developed is about 100 feet. It plunges southward about 25 feet per mile, gradually diminishing and disappearing near Fairbury.

Ransom syncline.—Lying between and essentially parallel to the LaSalle anticline on the west and the Odell anticline on the east is a broad syncline, herein named Ransom after the town of Ransom, Livingston County, which is situated on the axis (pls. 15, 19, 22, 24, 26; fig. 102). Its post-St. Peter axis trends S. 10° E. from the center of T. 37 N., R. 3 E., nearly to Ottawa, thence S. 25° E. from Ottawa to Ransom, whence it continues almost due south to Pontiac and thence S. 10-15° E. Its pre-St. Peter axis extends due north from Ransom. The differential elevation measured from the trough of the syncline at Pontiac to the crest of the LaSalle anticline due westward is between 250 and 300 feet and to the crest of the Odell anticline due eastward it is between 50 and 100 feet.

The syncline pitches to the south at the rate of from 25 to 50 feet per mile, apparently somewhat more steeply farther

³Athy, L. F., Geology and mineral resources of the Herscher quadrangle: Illinois Geol. Survey Bull. 55, fig. 27, p. 75, and pl. 1, 1928.

south, where it becomes a major structural depression between the LaSalle and Dwight anticlines.

Cedar Point anticline.—A symmetrical anticline, herein named Cedar Point after the town of Cedar Point which is situated on its axis, trends S. 65° W. from the LaSalle anticline south of Oglesby (pls. 15, 19, 22, 24, 26; fig. 102). The average dip on both limbs is about 200 feet per mile near the LaSalle anticline and about 100 feet per mile west of Cedar Point. The maximum differential elevation between the deepest portion of the Granville basin and the crest of the anticline about a mile southeast of Cedar Point is probably about 250 to 300 feet. A pronounced sag in the structure extends from two miles south of Granville to just east of the Illinois River near Putnam, in which the crest is about 150 feet lower than the crest south of Cedar Point and 100 feet lower than the crest south of Putnam. The anticline is not discernible over the crest of the LaSalle anticline but is probably continuous with the Marseilles anticline (pls. 15, 19; fig. 102) farther east.

Depue anticline.—A low, narrow, symmetrical anticline, herein named Depue after the town of Depue, Bureau County, which is situated on its axis, trends and plunges about S. 45° E. from north of Princeton to a few miles southeast of Depue where it disappears (pls. 15, 19, 22, 24, 26; fig. 102). The maximum differential elevation of the anticline, measured from the Granville basin three miles west of Spring Valley to the crest at Depue, is between 100 and 150 feet.

Hennepin syncline.—Between the Cedar Point and Depue anticlines lies a broad syncline, herein named Hennepin after the town of Hennepin, Putnam County, which is situated on its axis (pls. 15, 19, 22, 24, 26; fig. 102). The syncline trends and pitches eastward.

Peru anticline.—A narrow anticline, herein named Peru after the town of Peru, LaSalle County, which is situated on its axis, trends S. 35° W. from the LaSalle anticline a mile northwest of LaSalle to a short distance south of the Illinois River, where it apparently disappears (pls. 15, 19, 22, 24, 26, 29; fig. 102). The fold plunges very steeply to the southwest on

the west limb of the LaSalle anticline, but beyond that the plunge becomes much gentler, although more than 50 feet to the mile.

The maximum differential elevation is a little more than 100 feet. The fold is asymmetrical, with the dip of the southeast limb much steeper than that of the northwest limb, so steep in fact that it suggests the presence of a fault with the downthrow side on the southeast.

Oglesby syncline.—The structural depression that lies between the Cedar Point and Peru anticlines is herein named Oglesby syncline after the town of Oglesby, LaSalle County, which is situated in it. The syncline pitches steeply down the west limb of the LaSalle anticline and the sides dip strongly off the Cedar Point and Peru anticlines, but the trough of the structure is relatively flat with a gentle pitch westward (pls. 15, 19, 22, 24, 26; fig. 102).

Spring Valley anticline.—About two miles northwest of, and roughly parallel to, the Peru anticline there is a broad asymmetrical anticline, herein named Spring Valley after the town of Spring Valley, Bureau County, which is situated on its crest (pls. 15, 19, 22, 24, 26; fig. 102). The southeast limb of the anticline is much steeper than the northwest limb, which is hardly distinguishable from the west limb of the LaSalle anticline from which the anticline emerges. The anticline plunges gently southwestward.

Star Union syncline.—Between the Peru and Spring Valley anticlines there is a narrow syncline, herein named Star Union after the Star Union Brewery at Peru whose well reveals the magnitude of the structure (pls. 15, 19, 22, 24, 26; fig. 102). The syncline trends and pitches southwesterly parallel to the Peru anticline. It has a differential depression somewhat less than 50 feet.

Seatonville syncline.—Between the LaSalle and Depue anticlines there is a broad ovoid asymmetrical syncline, herein named Seatonville after the town of Seatonville, Bureau County, which is situated approximately on the axis of the structure (pls. 15, 19, 22, 24, 26; fig. 102). The trough of the syncline is 1600 feet below

the crest of the LaSalle anticline but only 100-150 feet below the crest of the Depue anticline, so that its east limb is that much steeper than its west limb. The syncline pitches in an arc southwestward, southward, and southeastward from the Minick anticline in southeastern Lee County to Illinois River, the degree of pitch steadily declining. The breadth of the syncline also decreases from north to south, being most constricted between the termini of the Depue and Spring Valley anticlines.

Granville basin.—The Hennepin, Seatonville, Star Union, and Oglesby synclines all pitch and merge in a closed structural depression, herein named the Granville basin after the town of Granville, Putnam County, which is situated within it. The basin has a closure of about 50 feet, below the sag in the Cedar Point anticline. It has an irregular five-lobed shape as a consequence of the tributary synclines and the intervening anticlines that plunge into it (pls. 15, 19, 22, 24, 26).

Minick anticline.—A symmetrical anticline, herein named Minick after a farm in Lee County on which is located one of the wells that define it, trends about S. 45° W. from the LaSalle anticline, of which it is in effect a protrusion across southeastern Lee County. The limbs dip about 200 to 300 feet per mile on the flank of and about 50 to 100 feet per mile farther from the LaSalle anticline. The anticline plunges southwest more than 250 feet per mile on the flank of and 50 to 100 feet per mile farther from the LaSalle anticline. The differential elevation of the top of the St. Peter formation between the J. H. Buckley well No. 1 in the NW. $\frac{1}{4}$ of sec. 21, T. 19 N., R. 10 E. and the Minick well No. 1 in the NE. $\frac{1}{4}$ of sec. 17 is 508 feet, and is about the same for the other formations (pls. 15, 19, 22).

Earlville sag.—A broad, shallow syncline, herein named the Earlville sag after the town of Earlville, LaSalle County, which is situated approximately on and near the east end of its axis (pls. 15, 19, 22, 24; fig. 102), trends S. 75° W. from Earlville. It pitches gently in the same direction as far as the LaSalle anticline near Mendota, beyond which it pitches steeply down the west limb of the anticline. The sag is not only a major deter-

minant of the present distribution of the Galena-Platteville formations in the vicinity of Mendota and Earlville (pl. 13) but also of the overlap of the Platteville strata on the St. Peter sandstone (p. 61).

Oswego syncline.—A broad, shallow syncline whose axis trends nearly due east-west across the north end of Kendall County is herein named Oswego after the town of Oswego that is situated nearly on its axis (pls. 22, 24; fig. 102). The syncline also pitches easterly and has a differential depression somewhat less than 50 feet.

Aurora syncline.—The southwest tip of a syncline trending northeasterly across the south end of Kane County, herein named Aurora because its axis passes near the city of that name (pl. 24, fig. 102), extends into the northwest township of Kendall County (T. 37 N., R. 6 E.), where it accounts for the presence of Silurian strata (pl. 13).

Sandwich fault.—In southeastern DeKalb and southern Kendall counties a fault, herein named Sandwich after the town of Sandwich, DeKalb County, through which it passes, strikes about S. 60° E. from Sandwich (pl. 13, 28). The downthrow side of the fault is to the northeast in amounts decreasing to the southeast: wells near Sandwich show that the Trempealeau dolomite abuts against the Galena-Platteville formations, representing a throw of 350 to 500 feet; of two wells only $\frac{1}{8}$ mile apart near the center of sec. 4, T. 36 N., R. 6 E., southeast of Sandwich, the northeast one penetrated 234 feet of Galena-Platteville strata whereas the southwest one penetrated only 50 feet of glacial drift on top of the St. Peter, although the difference in their surface elevations is only about 5 feet, revealing a throw of 150 to 200 feet; south of Yorkville, a well in the southeast quarter of sec. 13, T. 36 N., R. 6 E., penetrated less than 55 feet of Platteville limestone whereas a well less than half a mile northwest penetrated 180 feet of Galena-Platteville limestone, and as there is only a slight difference in the surface elevations of the two wells, the throw there is therefore only 75 to 150 feet. It is possible that the fault dies out entirely in eastern Kendall County or western Will County, but it is believed that it probably continues as the fault zone existing near Millsdale in Will County.

Stavanger syncline.—The north end of the Dwight anticline is limited on the northeast by a shallow syncline, herein named Stavanger after the hamlet in eastern LaSalle County that is situated in the trough of the syncline (pls. 15, 19; fig. 102). The syncline trends S. 60° E. at first and then curves southward to S. 15° E. It is most pronounced in its northern part where it is depressed nearly 100 feet below the crest of the Dwight anticline and where it includes a basin with a closure of 20-30 feet (pl. 12). The south part of the syncline pitches southward in gradually lesser degree until it disappears south of Illinois Valley.

Mendota anticline.—The differential elevation of the Galesville sandstone at Pawpaw and Earlville and the absence of Shakopee and New Richmond formations at Mendota indicate the existence of a pre-St. Peter anticline, herein named Mendota after the town in LaSalle County that is apparently situated about on its axis (pl. 15; fig. 102). The anticline trends southwesterly from the Kankakee arch through northwestern LaSalle and southwestern DeKalb counties, and it plunges southwesterly from the Kankakee arch and northeasterly from the LaSalle anticline to form a sag northeast of Earlville. Originally it probably plunged continuously southwestward, but the raising of the LaSalle anticline reversed its trend in part.

Morris syncline.—Differential elevations of the surface and differences in thicknesses of pre-St. Peter formations (pls. 15, 18, 19, 20; fig. 102) indicate that a broad, shallow pre-St. Peter syncline trends S. 20-25° E. across Grundy County. It is herein named Morris after the town of that name which is situated on the axis of the syncline. The syncline has a differential depression of about 50 feet and pitches southeasterly from the Kankakee arch.

Marseilles anticline.—Another pre-St. Peter anticline, herein named Marseilles because it passes near the town of Marseilles, trends generally S. 70° W. from about eight miles north of Morris to about four miles north of Marseilles, whence it swings in a broad arc south and west about two miles south of Ottawa (pls. 15, 18, 19, 20). The maximum differential

elevation on the top of the Galesville sandstone near Ottawa is about 100 feet. The anticline is nearly level and the limbs dip 50 to 100 feet per mile. It appears that southwest of Ottawa the anticline joins the Cedar Point anticline (fig. 102).

Dayton syncline.—The Marseilles anticline is limited on the west by a pre-St. Peter syncline, herein named Dayton after the town of Dayton, LaSalle County, which is situated on its axis, (pls. 15, 19; fig. 102). The syncline enters the region near Pawpaw and trends S. 55° E. to Fox River where it curves slightly west of south. It pitches in the same direction in increasing degree to attain a maximum depression near Ottawa, where it apparently terminates against the Marseilles anticline where the latter curves westward.

Ottawa anticline.—A symmetrical anticline, herein named Ottawa after the city of Ottawa which is situated on its axis, is most prominent in pre-St. Peter formations but persists in later formations (pls. 12, 15, 19, 22; fig. 102). It trends S. 20° E. through Ottawa, its limbs dip nearly 150 feet per mile, and it has a maximum elevation of about 250 feet.

Other pre-St. Peter structures.—Along Illinois Valley between Peru and Ottawa there are a number of small pre-St. Peter anticlines and synclines (pls. 18, 20; fig. 102), all of which trend S. 30-40° E. The two anticlines east of LaSalle appear to be steeper than the ones west of LaSalle, and their limbs dip about 50 feet per mile with a maximum differential elevation of about 75 feet. The folds apparently plunge and pitch northwesterly, but it is probable that there is a small amount of closure on each fold and that they plunge and pitch both northwesterly and southeasterly from the crest of the Marseilles-Cedar Point anticline.

Minor flexures.—Because more structural data are available for Pennsylvanian than for older strata, not only because they are penetrated by more borings but also because they are exposed in more numerous outcrops, both natural and artificial, small flexures that cannot be detected in the older, deeper formations can be mapped in the Pennsylvanian formations (pl. 12).

One of these small flexures is an anticline that trends southeasterly under Streator (pl. 12). It is a broad gently plunging anticline with a maximum differential elevation of about 50 feet and side dips up to about 20 feet per mile. Another similar anticline occurs about five miles north of Streator, and between the two anticlines is a consequent syncline of complementary magnitude.

A small narrow anticline and complementary syncline trends S. 20° E. across Illinois Valley just southwest of Ottawa. Their differential elevation is only 10-20 feet. At least two synclines, with complementary anticlines, appear to branch off of the Stavanger syncline northeast of Marseilles.

A similar minor anticline in beds older than Pennsylvanian occurs in the Galena-Platteville formations in the southwest corner of T. 37 N., R. 8 E., the northeast township of Kendall County. Its axis trends northwest-southeast and it has a differential elevation of about 20 feet (pl. 24).

Joints, minor folds, and faults.—Joint systems are rarely at right angles to each other, usually showing a variation of from 10° to 20° from the right angle.

There are two well-developed trends in the joint systems in the Marseilles, Ottawa, and Streator quadrangles—N. 50°-60° E., and N. 40° to 60° W. The first of these

two systems is the better developed and is approximately at right angles to the trend of the axis of the LaSalle anticline, with which the second forms an angle of 20° to 40°. There are also other joint systems which are less pronounced and occur less frequently than the above (table 7). Of these, one (table 7, No. 11) may be of especial significance, as it may reflect the influence of the Cedar Point anticline.

Small, localized folds occur frequently in the Pennsylvanian rocks of the quadrangles. Good examples are well exposed in two localities east of Vermilionville: (1) along the ravine near the center of the SW. $\frac{1}{4}$ sec. 10, T. 33 N., R. 2 E. (Deer Park Twp.), Ottawa quadrangle; and (2) along the ravine south of the road in the SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 9, T. 33 N., R. 2 E. (Deer Park Twp.), Ottawa quadrangle.

Faults of small displacement are also common in the Pennsylvanian strata. Most of these are normal faults, but a small thrust fault with about 2 feet of displacement cuts Pennsylvanian strata along the west side of Covell Creek in the SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 26, T. 33 N., R. 3 E. (South Ottawa Twp.), Ottawa quadrangle. A fault with a displacement of about 10 feet causes repetition of Summum and St. David strata along the ravine southeast of Dayton in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 32, T. 34 N., R. 4 E. (Rutland Twp.), Ottawa quadrangle.

TABLE 7.—TREND OF JOINT SYSTEMS

No.	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	Sec.	Twp.	Range	Quadrangle	Formation	NE trend	NW trend
1	SW	SE	NE	21	33 N	5 E	Marseilles	St. David "slate"	N 50 E	N 60 W
2	SE	NW	NE	24	33 N	4 E	Marseilles	St. David "slate"	N 60 E	N 45 W
3	NW	NE	NE	14	33 N	4 E	Marseilles	St. David "slate"	N 50 E	N 60 W
4	NE	NE	NE	2	33 N	3 E	Ottawa	St. David "slate"	N 50 E	N 45 W
5	SW	SW	SW	3	33 N	3 E	Ottawa	St. David "slate"	N 50 E	N 40 W
6	SW	NW	SW	27	33 N	3 E	Ottawa	St. David "slate"	N 50 E	N 50 W
7	NW	NE	NE	26	33 N	2 E	Ottawa	St. Peter sandstone	N 50 E	
8	SE	SE	SE	22	33 N	2 E	Ottawa	St. Peter sandstone	N 50 E	
9	NE	SE	SE	22	33 N	2 E	Ottawa	St. Peter sandstone	N 50 E	
10	SW	NE	SE	15	32 N	2 E	Streator	St. David "slate"	N 50 E	N 50 W
11	SW	NE	SE	8	32 N	2 E	LaSalle	Galena limestone	N 30 E	N 70 W*
									N 15 E	N 30 W
12	SW	NW	NW	31	32 N	3 E	Streator	Summum "slate"	N 50 E	N 45 W
13	SW	SW	SE	32	32 N	3 E	Streator	St. David "slate"	N 50 E	N 45 W
										N 20 W†
14	NE	NE	NE	16	31 N	3 E	Streator	Brereton "slate"	N 60 E	N 50 W†
										E—W†

*Most prominent.

†Weak.

CHAPTER VII—GEOLOGIC HISTORY PRE-PENNSYLVANIAN

BY
J. NORMAN PAYNE

INTRODUCTION

Geologic history tells the story of a changing earth—once mountains rose loftily where now lie flat prairies, broad sea-covered areas are the highlands of today, and thousands of feet of glacial ice buried the present sites of towering cities. This history has slowly unfolded as studies of the rocks have been extended throughout the world and as the events which they record have been interpreted in the light of knowledge derived from studies of earth processes active today. In the erosion by present streams, in the transportation and deposition of rock debris in rivers, lakes, and seas, in the action of volcanoes, in the erosion by glaciers and the deposition of moraines, in the formation of sand dunes along the shores of lakes and seas, we may observe rocks in the actual process of destruction and of formation and may determine the characteristics imposed by each environment. When we find the same characteristics in the ancient strata it is therefore possible to visualize the conditions that existed in those pre-historic times. Through countless ages these processes, now slowly molding the surface of the earth, have been actively wearing away the rocks in one area, building new ones in another.

Gravel, sand, silt, clay, and mineral matter in solution have been transported, worked over and assorted, and deposited beneath the seas, the coarser material being generally deposited near the shore and the finer farther from it. After consolidation by compaction and cementation, gravel becomes conglomerate, sand becomes sandstone, silt becomes siltstone, clay becomes shale, and chemical precipitates and organic secretions of calcium

carbonate become limestone, or dolomite if mixed with magnesium carbonate.

Cross-bedding, ripple- and rill-marks, channel-fills, etc., record water movements, and together with mud-cracks, rain-drop impressions, and worm-borings they record shallow-water conditions, beaches, and tidal flats. Widespread limestone formations indicate that the continents adjacent to the sea in which the limestone was deposited were low or that the place of deposition was far from the shore; coarse clastic sediments indicate that the continents were high or that the shore was near the place of deposition.

Warped, folded, or faulted strata record earth movements. Erosion between two epochs of marine deposition is recorded by irregular contacts (unconformities) between the formations deposited during those epochs, by evidence of weathering in the upper part of the older formation, by residual detritus in the base of the upper formation, or by the occurrence in the younger formation of fossils of organisms more advanced in their evolution than those in the older formation. In fact, the history of life development is traced by the changes in life forms revealed by the fossils in successively younger formations.

The lowest rocks in the geologic sequence (table 8) reveal the oldest chapter of geologic history, and the successively higher rocks provide an orderly record of the changing conditions. Needless to say, many events in earth history are obscure, and like much of early human history, their records have been destroyed by later events. The geologic history of Illinois is read partly from rock outcrops and partly from records of wells and borings within the State and is supplemented by knowl-

edge derived in the same way from adjacent regions. The sequence of rocks in the Marseilles-Ottawa-Streator area described in the chapters on stratigraphy is the principal source for the local history, although it has been supplemented by data from other areas, because processes which were operative within the area were generally also operative over considerable areas outside.

PRE-PALEOZOIC ERAS

Pre-Cambrian history is at best obscure, and in areas such as the Marseilles-Ottawa-Streator area where the pre-Cambrian rocks are deeply buried, it must be largely inferred. In areas where the pre-Cambrian strata are well exposed, as in the Lake Superior district, they record a series of periods of deposition of sediments alternating with periods of erosion, folding, and metamorphism—all interspersed with numerous occasions of widespread igneous activity. It is probable that a similar series of events took place in Illinois and in the Marseilles-Ottawa-Streator area. A long period of erosion immediately preceding the Paleozoic era developed the pre-Cambrian peneplain known in Wisconsin.¹ The present southward slope of the peneplain is due partly to the original slope of the plain, but mainly to subsequent diastrophic movements.

PALEOZOIC ERA

The Marseilles, Ottawa, and Streator quadrangles lie within the Central Interior basin. This basin was low-lying throughout the Paleozoic era and was frequently flooded by epicontinental seas. The intermittent elevation and depression of the area relative to sea-level created alternate epochs of erosion and deposition, the strand line varying radically many times and probably undergoing a minor amount of variation constantly. The sediments deposited in the area were derived chiefly from the Lake Superior region on the north, with minor contributions from the Ozark highland on the southwest and from the Appalachian highland on the east. Changes in deposition are recorded

in discordant or unconformable strata, changes in lithology, and changes in fauna as revealed by fossils in the rocks.

CAMBRIAN PERIOD

The long period of erosion that closed the pre-Cambrian evidently continued through early and middle Cambrian time in the Central Interior basin in Illinois as there are no formations of these ages known in the State. But by late Cambrian time the lowland was submerged, and sediments now comprising the St. Croixan series were deposited. Conditions of deposition were highly variable from time to time, and hence there is a wide variation in the lithology of sediments deposited. As the formations thicken to the south, and as the sediments to the south are more typical of offshore deposits than those to the north, it is believed that the sea encroached from the south.

MT. SIMON STAGE

The first deposits in the advancing sea were the coarse sands and conglomerates of the Mt. Simon formation. The five fairly well defined zones of the Mt. Simon (p. 54, fig. 31) reflect distinct but minor changes in the source of the sediments or conditions of deposition. The basal arkosic member may be a terrestrial rather than a submarine deposit, and it may be older than Mt. Simon in age (p. 54).

Eau Claire Stage

An abrupt and more important change in conditions brought about the deposition of the finer sands, dolomites, and shales of the Eau Claire formation. A peculiar depositional environment must have existed at the beginning of Eau Claire time to cause the precipitation of the finely divided pyrite which encrusts the grains of sand in the lowest zone. Possibly conditions were much the same as in the Black Sea² of today where the combination of stagnation and the activity of certain organisms gives rise to the precipitation of finely divided pyrite. The abundance of linguloid brachiopod and trilobite remains in this zone suggests

¹Wiedman, S. and Schultz, A. R., Water supplies of Wisconsin: Wisconsin Geol. and Nat. Hist. Survey Bull. XXXV, p. 26, 1915.

²Andruscow, N., La Mer Noir: Guide des excursion de 7 Cong. Geol. Internat. No. 27, 1897.

TABLE 8.—GENERAL CLASSIFICATION OF GEOLOGIC TIME

Era	Subera	Period	Epoch	Subepoch	Stage
Cenozoic	Quaternary	Pleistocene	Eldoran		*Recent *Wisconsin
			Centralian		*Sangamon *Illinoian
			Ottumwan		Yarmouth *Kansan
			Grandian		**Aftonian Nebraskan
	**Tertiary	Pliocene Miocene Oligocene Eocene			
Mesozoic		Cretaceous Jurassic Triassic			
Paleozoic		Permian			
		Pennsylvanian		*McLeansboro *Carbondale *Tradewater **Caseyville	
		Mississippian	Chester		
			Iowa	Meramec Osage *Kinderhook	
		*Devonian	Chautauquan Senecan Erian Ulsterian Oriskanian Helderbergian Cayugan		
			*Niagaran		Port Byron Racine Waukesha Joliet
					Kankakee Edgewood
		Ordovician	Cincinnatian		*Maquoketa
			Mohawkian		*Galena *Decorah *Platteville *Glenwood
			Chazyan		*St. Peter
			Prairie du Chien		*Shakopee *New Richmond *Oncota
		Cambrian	St. Croixan		*Jordan *Trempealeau *Franconia
				Dresbach	*Galesville *Eau Claire *Mt. Simon
Proterozoic (Algonkian)		Keweenawan Huronian			
Archeozoic (Archean)		Keewatin			

*Formations and larger divisions definitely identified in North Central Illinois.

**Formations and larger divisions possibly present in North Central Illinois.

decimation of these organisms due to the high salinity of the water. Succeeding the deposition of the first zone was a period during which finer sand, mud, and calcareous material were deposited, with the proportionate amount of calcareous material increasing toward the end of the Eau Claire stage. As glauconite is believed to be the result of organic activity,³ which is discouraged by relatively rapid sedimentation, the occurrence of abundant glauconite in the Eau Claire formation is thought to indicate relatively slow deposition.

GALESVILLE STAGE

Conditions similar to those of the Mt. Simon stage recurred during the deposition of the coarse sands of the Galesville formation, although the presence of some calcareous materials probably indicates that the waters in which they were deposited were more quiescent. Minor local movements are reflected in the variations in thickness of the Galesville.

FRANCONIA STAGE

After the deposition of the Galesville formation the conditions again changed to favor the deposition of the finer sand, shale, and dolomite, and abundant glauconite of the Franconia formation. There was some reworking of the Galesville sand so that the basal Franconia strata are similar in texture to those of the Galesville but differ in that they contain appreciable amounts of glauconite.

TREMPEALEAU STAGE

During Trempealeau time the seas cleared and in them were deposited chemical or organic precipitates or both which later became the dolomite of the formation. The three well-defined glauconitic zones (see Chapter I) again probably represent periods of slower deposition. The chert that is present in the formation may be primary, that is, deposited as colloidal silica at the same time as the rest of the formation, or it may be secondary, that is, have replaced the dolomite subsequent to the consolidation of the formation.

JORDAN STAGE

At the beginning of the Jordan stage there was a retreat of the sea or some uplift of the bordering land mass to account for the sand that occurs at the base of the formation. During the Jordan stage there were very minor advances and retreats of the sea giving rise to alternating layers of clastic and calcareous sediments.

The Cambrian period in the Central Interior basin was terminated by an uplift of the region above sea-level and a succeeding period of erosion during which the Jordan formation was deeply eroded.

ORDOVICIAN PERIOD

PRAIRIE DU CHIEN EPOCH

ONEOTA STAGE

The Ordovician period began with a readvance of the sea. During the Oneota stage the sea was relatively clear as indicated by the dominantly calcareous material that composes the formation. Sometime near the middle of the stage, conditions were altered so that the deposition of glauconite took place. In the latter part of the stage the addition of clastic material became marked and was probably a forecast of the conditions that were to be attained during the New Richmond stage.

NEW RICHMOND STAGE

Either after the Oneota and before the New Richmond stage or during the New Richmond stage, the Marseilles anticline began to rise, accompanied by some movement along the subsidiary anticlines. The movement of this anticline continued at intermittent intervals throughout New Richmond, Shakopee, and St. Peter times, as shown by the thinning of these formations over the anticline. Formations younger than the St. Peter, other than Pennsylvanian and Pleistocene, have been removed or deeply eroded so that there is no direct evidence whether or not the movements continued after St. Peter time. However, if the Marseilles anticline is a continuation of the Cedar Point anticline, the movements of the latter are indirect evidence that the former continued to rise until at least the end of the Silurian period.

³Twenhofel, W. H., *Treatise on sedimentation* (1st ed.), pp. 337-341, 1926.

The conditions of deposition favored the accumulation of sand throughout most of the New Richmond stage, but at intervals conditions locally favored the deposition of calcareous material.

SHAKOPEE STAGE

After the deposition of the New Richmond sand there was a marked clearing of the seas with conditions again favorable for the accumulation of calcareous material. Evidence of shallow-water deposition during the Shakopee stage is found near Franklin Grove, Lee County,⁴ and in the LaSalle quadrangle.⁵

POST-SHAKOPEE PRE-ST. PETER INTERVAL

The close of the Prairie du Chien epoch was marked by the uplift of the Kankakee Arch⁶ and related structures, such as the Marseilles and Mendota anticlines and the small anticlines across Illinois Valley (pls. 15, 19, fig. 106), as well as minor flexures elsewhere present in the Shakopee but not in the St. Peter formation⁷. These movements were accompanied or immediately followed by widespread erosion which removed all of the Shakopee and New Richmond formations and much of the Oneota formation in the uplifted portion of Illinois northeast of the arch, truncating these formations as they rise on the southwest limb of the arch (pls. 13, 18, 19, 20), and cut into the lower formations down at least as far as the Trempealeau. The erosion apparently occurred in two stages, the first being carried to virtual peneplanation in the uplifted northeastern region and the second, a rejuvenation, carried well into youth or early maturity.

A well-developed river system was formed in the eastern part of Livingston and southern part of Grundy counties (pl. 21), the data available indicating that the stream flowed to the southwest.

⁴Knappen, R. S., *Geology and mineral resources of the Dixon quadrangle*: Illinois Geol. Survey Bull. 49, pp. 82-85, 1926.

⁵Cady, G. H., *Geology and mineral resources of the Hennepin and LaSalle quadrangles*: Illinois Geol. Survey Bull. 37, p. 92, 1919.

⁶Ekblaw, George E., *Kankakee arch in Illinois*: Geol. Soc. America Bull. vol. 45, pp. 1425-1430, 1938.

⁷Cady, G. H., *Structure of the LaSalle anticline*: Illinois Geol. Survey Bull. 36, pp. 111-112, 1920.

This river system extended headward at least as far as Joliet.⁸ A deep tributary to it, flowing either south or east, crosses Grundy County at Morris (app. C, 17 and pls. 18, 20, 21, 28, 29). Other tributaries are also evident. Recent studies in the Elgin, Barrington, and Geneva quadrangles show that another large river system drained eastward across that area.⁹

CHAZYAN EPOCH ST. PETER STAGE

The Chazyan epoch opened with a re-advance of the sea over a region having erosional topography and a mantle of regolith of varying thickness. This residual material was reworked by the advancing St. Peter sea and formed the initial deposit of the Chazyan epoch.

Conditions remained stable throughout the deposition of the St. Peter as reflected in the succession of sand that composes the formation. The characteristic rounding and frosting of the sand grains have been cited as evidence that the formation is mainly an eolian deposit, possibly in a desert adjacent to the sea, but other evidence demonstrates that it is mainly marine, and the grain characteristics are probably the result of a long and complex history involving many earlier cycles of erosion and deposition.^{10, 11} Some recurrent uplift of the Marseilles anticline during the St. Peter stage is reflected in the thinning of the St. Peter sandstone over it. The St. Peter stage was terminated by a slight, apparently local, emergence, probably accompanied by some local folding, as there is evidence of an erosional unconformity between the St. Peter and overlying Platteville or Glenwood beds in some areas¹² and of an overlap in the vicinity of LaSalle and Ottawa (p. 61), whereas at other places there seem to be transitional beds between the St. Peter and overlying Glenwood formations.¹³ The

⁸Fisher, D. J., *The geology and mineral resources of the Joliet quadrangle*: Illinois Geol. Survey Bull. 50, pp. 14-20, pl. III, 1925.

⁹Gries, P., *Subsurface geology of Elgin, Geneva, and Barrington quadrangles*: Illinois Geol. Survey unpublished manuscript.

¹⁰Dake, C. L., *The problem of the St. Peter sandstone*: Univ. of Missouri School of Mines and Metallurgy Bull., tech. series, VI, No. 1, 1921.

¹¹Lamar, J. E., *Geology and economic resources of the St. Peter sandstone*: Illinois Geol. Survey Bull. 53, pp. 26-29, 1928.

¹²Elder, Stanley G., *Stratigraphy of the Glenwood formation*: Illinois Geol. Survey unpublished manuscript.

¹³Bevan, A. C., *The Glenwood beds as a horizon marker at the base of the Platteville*: Illinois Geol. Survey Rept. Inv. 9, 1926.

overlap is apparently the result of uplift along the Marseilles anticline and other smaller anticlines at the close of the St. Peter stage, sufficient to make a local land area in Glenwood and early Platteville times, and is probably not the result of movement of the LaSalle anticline before the beginning of Mohawkian time as has been cited.¹⁴

MOHAWKIAN EPOCH

GLENWOOD STAGE

After the brief and local emergence of land at the close of the St. Peter stage the sea again inundated the area, reworking the St. Peter sand and depositing additional fine material to create what is called the "typical Glenwood texture". In addition some mud was locally deposited and now forms the shale of the formation. In the late part of the Glenwood stage the seas became clearer and calcareous material with some admixed clastic detrital materials was deposited.

GALENA-PLATTEVILLE STAGES

Gradually the sea became still clearer, and calcareous material with no sand and very little mud was deposited during the Platteville-Galena stages. There was a slight fluctuation of conditions during the Decorah stage, however, which brought about the contribution of some detrital material which gave rise to the shale partings and the argillaceous and rarely sandy character of the formation. Also conditions existed locally which were favorable to the deposition of oölites. It is believed that dolomitization of all the formations took place after their deposition and consolidation.

The Mohawkian epoch was closed by slight uplift of the region.

CINCINNATIAN EPOCH

After a short period of emergence after the Mohawkian epoch, the Marseilles-Ottawa-Streator area was again submerged by a sea that advanced from the north.¹⁶ Conditions at the beginning and

in the earliest part of the Maquoketa stage favored the accumulation of silt and mud with a minor amount of calcareous sediment; in the middle of the stage, the seas became clearer and the deposition of calcareous material became dominant; and during the last part of the stage, conditions reverted to those which existed in the earliest part so that again much mud and silt with negligible amounts of calcareous material were deposited.

Either during or at the close of the Maquoketa stage the Cedar Point anticline was elevated, as shown by the pronounced thinning of the Maquoketa formation in the well at Cedar Point (pl. 25).

The Ordovician period was closed by an elevation of the entire region above sea-level, followed by erosion of the Maquoketa formation.

SILURIAN PERIOD

ALEXANDRIAN EPOCH

After an erosional interval of long duration the area was again inundated in the Alexandrian epoch by waters that advanced from the Gulf of Mexico.¹⁷ During the early part of the epoch, in the Edgewood stage, the material deposited was largely clastic, but later, during the Kankakee stage, the seas became very clear and little or no clastic material was deposited. In the latter part of the Kankakee stage the water was probably clearer than at any other time in the Silurian period, because in other parts of northern Illinois insoluble residues are practically absent from the top of the Kankakee formation.¹⁸

NIAGARAN EPOCH

There was a shallowing of the seas at the beginning of the Niagaran epoch, and a marked increase of clastic material was contributed to the sediments. At this time a connection was established with

¹⁴Cady, G. H., op. cit., Bull. 36, p. 175.

¹⁶Savage, T. E., Richmond rocks of Iowa and Illinois: Am. Jour. Sci., 5th Ser., vol. 8, pp. 411-427, 1924.

¹⁷Savage, T. E., Silurian rocks of Illinois: Geol. Soc. America Bull., vol. 37, pp. 513-534, 1926.

¹⁸Workman, L. E., personal communication.

seas to the north.¹⁹ After the earliest part of the Niagaran epoch the seas became clearer and the amount of clastic material decreased. The widespread chert that occurs in the Niagaran series was formed partly by precipitation from circulating groundwaters subsequent to consolidation of the dolomite and partly by direct precipitation from the sea-water during the deposition of the calcareous material.²⁰

The Niagaran epoch was closed by widespread emergence, accompanied by a recurrent movement along the Cedar Point anticline as reflected in the thinning of the Silurian system. The region remained land throughout the Late Silurian epoch, for there are no deposits of this age known within the area.

DEVONIAN PERIOD

The land conditions that existed in Illinois during the Late Silurian epoch probably continued through the Early and Middle Devonian epochs, as the Devonian rocks in the area are believed to be of Late Devonian age. The area was probably submerged by the Late Devonian sea, and conditions favored the accumulation of calcareous material with a minor amount of mud.

The Devonian period ended with the emergence of the area.

¹⁹Savage, T. E., Alexandrian rocks of Illinois and Wisconsin: Geol. Soc. America Bull., vol. 27, p. 314, 1916.

²⁰Fisher, D. J., Geology and the mineral resources of the Joliet quadrangle: Illinois Geol. Survey Bull. 51, pp. 41-44, 1925.

POST-DEVONIAN

PRE-PENNSYLVANIAN TIME

Little is known of the events that took place in north-central Illinois between the close of the Devonian and the opening of the Pennsylvanian periods. Although Mississippian rocks are found in the Henry city well, it is possible that the Mississippian seas never advanced completely over the region.

Sometime between the close of the Devonian and the beginning of the Pennsylvanian periods the major folding of the LaSalle anticline took place. From evidence in areas to the south, it seems probable that this deformation took place in late Mississippian time.²¹

The rise of the Depue, Dwight, and Odell anticlines and additional movement along the Kankakee arch, accounting for the exposure of Cambrian rocks near Millington, and other pre-existing folds, took place at this time. The Sandwich fault was probably formed as a result of subsequent relaxational movements. In late or post-Pennsylvanian time there was a second and more intense period or periods of compression which marked the climax of the folding of the LaSalle anticline. Probably all of the structural units involved in the first period of folding were again affected.

²¹Payne, J. Norman, The Age of the LaSalle anticline: Trans. Illinois Acad. Sci. vol. 32, No. 2, 1940; Illinois Geol. Survey Circular 60, pp. 5-7, 1940.

ERRATUM

Page 195, second column, last paragraph, fourth line.

The phrase:

"the exposure of Cambrian rocks"

should be changed to read:

"the exposure of Ordovician rocks"

